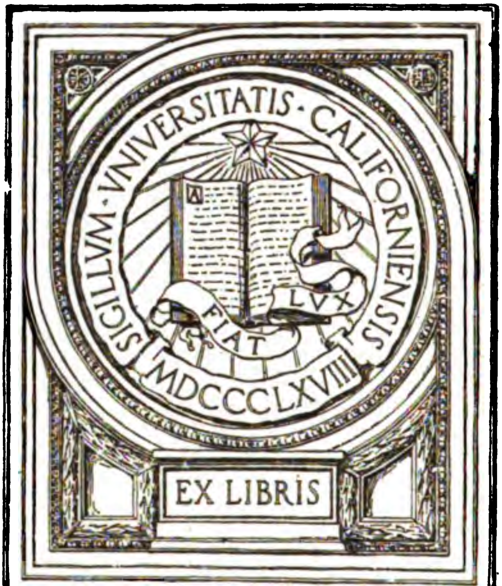
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Annual Report for 1904.

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The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

Investigation of the Great Plains.

Unirrigated Lands of Eastern Colorado.

Seven Years' Study.

—BY—

J. E. PAYNE.

PUBLISHED BY THE EXPERIMENT STATION
Fort Collins, Colorado.
1903.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

Twelve-foot binder at work near Wray, Colo.

A part of the orchard, and residence at the Plains Substation.

Unirrigated Lands of Eastern Colorado.

Based on a Study and Residence of Seven Years.

By J. E. PAYNE, M. S.

After spending seven years on the Plains, three of which were devoted to traveling and making a special study of the country, and collecting information concerning the results obtained by settlers, we give the statements contained on the following pages to the public.

We are often asked, "Can a man make a living on the Plains?" The only answer which can be safely returned is, "It depends upon the man."

Soil. The soil of the country is quite fertile, as a rule, and whenever it is watered sufficiently at the proper time—either by rainfall or irrigation—abundant harvests are reaped. The most of the soil of the region would be classed as sandy loam. But there are large areas of heavy clay soil, and some which is called "adobe." With some exceptions, the more clay there is in the soil, the more water is needed to raise a crop upon it. Good crops have been raised on some dark sandy soils with very little rainfall. On the "adobe" soil "dry farming" is a failure.

Rainfall. The average rainfall of the country is between fifteen and twenty inches. Records kept for a few years indicate that it is not far from seventeen inches, but they have not been kept long enough to be considered reliable.

Wind. During only a few days in any year is there a dead calm. There is nearly always a breeze, varying in velocity from four to forty miles per hour. At first, this seems hard; but when we consider that nine-tenths of the stock must depend upon water pumped from deep wells, we realize that the wind is an extremely valuable free power, and decide to put strings on our hats and not complain.

Sunshine. Eastern Colorado is eminently a land of sunshine. Very few cloudy days occur. Probably, 300 days in the year are

clear days. If the sun-motor is ever perfected, it will be a great help to this region, for on days when the wind does not blow the sun shines, and the sun-motor would do the work now done by horse-powers and gasoline engines.

Hail. During the eight years we have been at work at Cheyenne Wells, several hailstorms have struck the place. However, no hail sufficiently severe to kill the trees has yet struck there. We doubt that fruit trees and crops generally are destroyed by hail any more frequently there than in irrigated regions of Colorado.

Natural Vegetation. Vegetation grows according to the water supply. Most of the country is covered by short grass. In some places, not more than one-fourth of the ground is covered, while in other places where extra water runs on from surrounding land, the grass makes a complete mat, covering the whole surface. The sand hills and the black sandy land support a variety of tall-growing grasses, which usually grow in bunches, but often grow two to three feet high. The low places often support different species of Agropyron, or Colorado Bluestem — which starts early in the season and matures early in July — making its growth during the season of maximum rainfall. This grass is called "wheat grass" by many, and its habits may be a hint for those who wish to depend upon wheat raising in the plains region. Some do think that if they could get a variety of wheat which would mature by July 4th, it would be practically sure to produce a crop every year. The region between the Arickaree and the North Fork of the Republican River, lying east of the sand hills, appears like a piece of country taken from two hundred miles east of its present location and set down in Eastern Colorado. Along the Black Wolf and Dry Willow are fringes of trees and plum thickets, and wild grapes are quite common there. The rainfall is about the same as in other parts of the Plains.

Water. The water courses of the Plains are mostly sinuous lines of sand of width rudely proportionate to the areas drained. They may carry no water for one or two years, and then a heavy rain may come which changes them to raging torrents. The water does not *run* down their courses; it just tumbles, scooping out great holes here and making immense sand dykes there. If there is enough water, some of it joins some running stream, but as frequently, it tumbles along over the sandy bed until all is used in saturating the upper layers of sand. The surplus caught in the water holes goes into that indefinite, much-dreamed-of body of water called the underflow. Sometimes this underflow of the plains streams follows the course of the present sand-bed, and sometimes it does not. The Plains seem to have an infinite num-

ber of underground streams of varying width. Some are very narrow, and some are so wide that there are regions which are said to be underlaid by "sheet-water." This suggests the possibility of the existence of an underground water system consisting of rills, creeks, rivers and lakes on the Plains. Also, in the same connection, it must be admitted that hills and mountains exist there. If we could strip the country of the soil so as to uncover the shale beds and water bearing sands, it is likely that we would discover a country not so level as now exists there, but with many hills which are now under hollows, and many streams of various sizes trickling through beds of sand much the same as the waters of the Big Sandy pass through its vast sand bed. There are now quite a number of streams in Arapahoe, Washington and Yuma counties whose outlets are covered by sandhills. One of these in Washington county is over two hundred feet wide where the B. & M. railroad crosses it, but it ends on the west side of a big sandhill. The visible streams of water are few. The Big Sandy shows open water at intervals along its course. This stream seems to have an underflow which follows the course of its sand-bed, although it seems to be much wider in places. The Smoky Hill River in Colorado is crossed at intervals by an underground stream which does not follow the course of the present sand-bed any great distance at any place. The South Fork of the Republican is a visible stream for a few miles just east of Flagler, where it runs over a bed of shale. It then goes under the sand, and does not again appear until near Tuttle. From Tuttle to Benkelman, Nebraska, where it joins the North Fork of the Republican, it is a visible stream. The Arickaree River rises near River Bend. It has no known underflow corresponding to its sand-bed until within a few miles of Cope, at the townsite of Arickaree City. Open water appears several miles below Cope, and a small stream is constant in flow between that point and Haigler, Nebraska, where it unites with the North Fork of the Republican. The North Fork of the Republican is a good stream from its source. It is formed by the union of several spring streams in the sand-hills west of Wray.

When the country was occupied by the stockmen, they took possession of the open water, using the range as far out on the flats as their stock could graze from water. They sometimes pushed their cattle out onto the flats when the lagoons were full of water from rains, but as a rule the flats were not used very far from the streams. Those men seem to have seldom thought of pumping water from deep wells for their stock. But, when the country was settled by farmers, they began to dig deep wells. Their necessities caused the introduction of well-augers and well-drills and powerful force-pumps. Windmills were also improved to meet the needs of the times. Soon wells were found in large

numbers on "the flats," which before could be occupied a short time only each year by cattle on account of scarcity of water. Now almost every settler has his own well and windmill, and the grape vines and cherry trees are increasing.

Settlement. The tide of settlers which filled Western Kansas in 1883 to 1885 overflowed into Eastern Colorado in 1886 and 1887. Kiowa and Cheyenne counties were settled thinly; Kit Carson county was nearly all filed upon—especially the eastern half of it; the Idalia and the Vernon divides were settled thickly—all land on the Vernon divide being filed upon, and all as far west as Kirk postoffice on the Idalia divide being occupied. Then, on the west of the sandhills, the country near Thurman, Lindon and Harrisburg was all taken up. All land near lines of railroad—either real or projected—was taken also. Washington county was thickly settled along the B. & M. railroad.

Successes and Failures. The years 1888 and 1889 were quite good years for crops, 1890 was not so good, but 1891 was better, and in 1892 such an immense crop was raised that the settlers called the land "God's country" and wondered why people remained on rented farms in the East when so much free land lay out in this region "only waiting to be tickled by the skill of the husbandman to yield bountiful harvests." Then, people planned large things and went in debt accordingly. Then came the partial failure of 1893, and following this the complete failure of 1894. The year 1895 was much like 1893. In 1893, many left the country. More left in 1894, and in 1895 nearly all who could get away, went. Those who stayed received some help from friends, and worked together to help themselves, and in this way lived through. Each year since 1895, they have raised fair crops. But recognizing the fact that the cows and the hens had saved the country from returning to its old time use as a cattle pasture, the settlers have taken to stock raising, and now the country is upon its proper feet. When the settlers first came in, they attempted to live by grain farming alone. They were taught that grain growing is not the proper basis of successful agriculture on the Plains. They have learned that farming without stock soon impoverishes the man in this country. The country is now resting upon the three legs which are strong enough to sustain it, if used intelligently, through all generations. These are stock, winter forage and summer pasture. It is possible that they may use some cows for dairying when beef cattle prices again go as low as they were in 1889-'94. But the cows are in the country, and they are well distributed now so that no one need leave because he has no cow to tie to.

CROPS GROWN.

Sorghum. Sorghum, including the sweet and non-saccharine varieties, is successfully grown without irrigation everywhere in the region except on adobe soil. The average yield per acre is about one ton, taking a series of years for a test. Only the earliest varieties produce seed. Brown durra, Jerusalem corn, Yellow Milo Maize and some strains of Early Amber cane produce seed; but Red and White Kafir, Early Orange, Colman, Collier and all later varieties of cane and Kafir corn produce very little seed; but these all give good yields of fodder. We find more cane being planted each year we travel. The acreage of sorghum in a neighborhood where crop raising is attempted at all, is a fair index to the status of the cattle raising industry there. In 1900, very little sorghum was planted on the Vernon divide, but in 1902 I saw quite large fields of it.

Millet. This crop is widely grown, and in some neighborhoods is more popular than sorghum. It is not nearly so sure a crop as sorghum, and therefore cannot be depended upon to give a crop every year in all localities. It may be just as sure as sown sorghum, but is not nearly so certain to produce a crop as cultivated sorghum. The average yield of millet will not exceed one-half a ton, and it may not be more than one-fourth of a ton per acre, taking a term of years all over the plains upon which to base an estimate.

Corn. Corn is grown as widely as sorghum, although it is somewhat unpopular in some localities. Over most of the territory a variety is in use which has been developed by the conditions peculiar to the region. It is a low-growing Flint corn. The ears often set on the stalks barely above the surface of the ground. This corn suckers bountifully, so that if the season is a wet one there will be quite a bunch of stalks from the two or three grains planted in one hill. The ears are long, and the cobs large. The grains are so hard that the corn should be either ground or soaked before being fed to horses or cattle. Hogs seem to enjoy grinding the grains, and do well on it, as it seems to be especially rich in protein. This variety, called Mexican corn, is generally grown in the region, except on the Vernon and Idalia divides, where they usually get better results by growing Dent varieties. Outside of the Vernon and Idalia divides, and the black sandy land, the yield of corn is hardly worth mentioning, although some years forty bushels per acre are produced. But the price of grain is usually so high that a very small yield will pay for the work of raising it, and they count upon getting fodder anyway. The average yield of corn on the Vernon divide is probably twenty bushels per acre. On the Idalia divide it will probably average fifteen bushels in a

Grout house of J. Schaal, near Yale, Colorado.
Corrals of J. Schaal, near Yale, Colorado.

series of years. Some years yields are much higher than these figures, and some men may have attained yields averaging much above this for a long term of years, but for the whole district these figures are not far from correct. Some men, single-handed, are cultivating one hundred and fifty acres of corn by the use of improved machinery and a good supply of horses.

Wheat. Wheat growing as a specialty is almost a thing of the past in Eastern Colorado. Men have learned that planting wheat after wheat continuously does not pay. This year we found that wheat following corn yielded about double what wheat following wheat was yielding. This has made corn growing more popular, reduced the acreage of wheat, and has forced people to diversify their crops and engage more and more in general farming, with stock raising as a basis. The yield of wheat on the Vernon divide averages about ten bushels per acre. On the Idalia divide the average is about eight bushels. In the remainder of the territory wheat is so seldom threshed that it would be unfair to publish any estimate, as as high as forty bushels per acre have been harvested, and many years the wheat has been cut for hay when very fair yields might have been obtained. In fact, during the past five years, wheat has been sown more for hay in Kit Carson county than for grain.

Oats. Oats are sown for hay in eastern Kit Carson county, and more or less in all other neighborhoods, except the Vernon and Idalia divides. On the Vernon divide oats average about twenty-five bushels per acre, and on the Idalia divide about twenty bushels.

Barley. This crop is not sown much anywhere in the region studied. The variety raised is one used for feed. Very little is sown outside the Vernon and Idalia divides. There, the yield is usually a little better than the yield of oats.

Rye. Some early varieties of spring rye seem to be gaining favor as a hay crop. There was more rye grown in 1902 than in any other year we have traveled on the plains.

Spelt. This grain is gaining favor also. In July, 1902, I saw a field of fifteen acres of spelt near Vernon.

Trees. Honey locust, black locust and ash are the trees which do the best on the Plains, although elms seem to do quite well if planted among other trees. The hackberry is a native on the Plains, but I have never seen any growing except near streams, or where water was close to the surface. Nearly all the timber claims planted in the early settlement of the country have been abandoned. Just enough trees are alive to show what trees can be

depended upon if given extra care. Upon this subject very little can be added to what was said in Bulletin 59.

Fruit. Of the thousands of orchards planted, only a few trees are alive to show what kind of fruit can be raised in the country. Continued observation has merely confirmed the statements made in Bulletin 59. Gooseberries, native currants, plums and cherries are reasonably sure to produce crops if given especial care. Apples will give crops periodically if not irrigated, and if irrigated are as sure as in other localities. Fruit gardens with facilities for irrigating from wells are growing in numbers year by year.

Irrigation from Wells. As wells are from 80 to 260 feet deep, only very small areas can be profitably irrigated from them. But nearly every settler now tries to have a few square rods of irrigated garden near the well. Some were extremely successful and some were failures; but each succeeding year shows an increase in the number of successful ones. If the sun-motor which is now being worked upon is ever perfected, it may revolutionize the problem of irrigation from deep wells. The main problem will then be to find enough water underground to supply the pumps.

Irrigation from Streams. A few hundred acres are irrigated from each of the main streams. Engineers who have made surveys claim that the flow of the streams is not sufficient to pay for taking the water out onto the flats, and the regular flow is already appropriated for land in the valleys anyway. The fall of the country is so great that ditches two to five miles long would carry the water out onto the flats most anywhere in their courses. If irrigation is ever developed in this region, it must be by catching and holding storm water for use. If a system of low dams for turning the flood water of these streams into reservoirs could be built, beginning at the sources, 5 to 10 per cent. might be irrigated. But this would involve a large outlay of money and labor, and it is to be thought of as a long way in the future. The country is developing along lines of least resistance now, and it is likely to continue in the same way.

Neighborhoods. Kiowa, Cheyenne and Kit Carson county, south of the Rock Island railroad, are quite thinly settled, and stock raising with very little winter feeding is the rule. Only a small quantity of this land has been homesteaded. Settlers live from two to ten miles apart. When claims join, they try to divide the range. Along visible streams and known underground water-courses the land is usually all taken and the stock range over the unoccupied land on each side of the settlement.

Kit Carson county, north of the Rock Island railroad, was quite thickly settled in the eastern half of the county. The settlers who still live there are from one to five miles apart. At Yale postoffice there is a small district which is settled solidly. Crop failures in 1893 and 1894 thinned the settlement. In some neighborhoods, the depopulation was made permanent by uncertain water supply. The settlers now in Kit Carson county have settled down to stock raising with farming as a side issue. There are still a few men who say that they cannot afford to raise feed for their cattle any more than enough to carry them through the storms.

Arapahoe county on the Idalia divide as far west as Kirk postoffice was all filed upon. Settlement thinned in 1893-95 on account of crop failures, but people are still too close together to keep their cattle at home during the summer. It is the custom to send the cattle to the thinly settled districts for pasture. On this divide wells are plentiful, but they are from 100 to 260 feet deep.

The Vernon divide lost much of its population in 1894 and 1895, but has regained it since. Practically all of the land on this divide is in private hands, and unimproved land is selling at $1,000 per quarter section. Except upon a small area of about twelve square miles south and southeast of Vernon, wells are sure on this divide. Water is found at from 90 to 100 feet.

Lindon and Harrisburg lost all population except a few families. Within the last two years some good wells have been found in the neighborhood, and a few ranchmen have quite a number of cattle in the neighborhood now.

Near Akron and Yuma, and along the B. & M. railroad, where nearly all the land was once filed upon, settlers are from two to eight miles apart now. But there is a tendency for new settlers to crowd in there again.

THE LIVE STOCK INDUSTRY.

From the nature of the conditions the live stock industry must always be the main business on the plains. The problem before those who would use the country is: How much stock can be kept on a specified area?

The methods of handling stock are changing gradually from the range system with no feed, to feeding with winter shelter. As the ranges become more crowded, more feed is used during winter. Evidence now seems to show that much of the country will at some time be used as a summer range only, and the cattle will be fed during the winter in adjoining districts where crops of forage are raised.

There is a growing feeling among the wealthier cattlemen that it pays best to use their ranges for the summer only, and bu

young stock in the spring to be sold in the fall. Others are taking up the idea of producing forage on a large scale so that they can feed all stock whenever it is necessary. Still others count upon moving all cattle to where there is plenty of feed and hiring them wintered. It is noted that farmers on the Vernon divide now often take cattle to winter. But the greatest number of cattle will undoubtedly be raised by men who own bunches of from twenty-five to one hundred and care for them by the work of themselves and their families. These people can make a living by milking a few cows when cattle are low in price, and then they can turn the milk more towards beef making when cattle are high.

My travels on "the divide" south of Denver gave me some idea of the possibilities of the dairy business on the plains. Some of the settlers on the plains are now using hand separators and shipping their cream. This simplifies dairying and leaves the skim milk at home for the calves, and at the same time it materially lessens the labor connected with dairying.

Poultry. Some people have made quite a success in raising poultry. The sunshine of the plains, when combined with proper feed and care, makes the laying hen extremely popular. The production of winter eggs, combined with winter dairying, has proved extremely profitable on a small scale in a great many cases. One woman who kept accounts showed me a record of 100 hens for a year. The eggs had given a profit of one dollar per hen for the year, and she had raised 190 chicks besides. Another woman raises several hundred chicks every year, using incubators and brooders. She buys the eggs for hatching from her neighbors as she keeps no roosters. All young roosters are sold when they reach broiler size. The pullets are kept for the production of winter eggs. She raises mostly Leghorns. Of course, there have been many failures in the poultry business on the plains also—failures too numerous to record. Those who succeeded in the poultry were very careful hands, and they have made a thorough study of the business from the beginning.

GENERAL OBSERVATIONS.

Since beginning the investigations, the country has been constantly improving. The houses built of sod from sandy loam soil do not usually stand much more than fifteen years, while those made of adobe soil last indefinitely. However, the sod roofs soon become leaky and need frequent replacing. We find many sod roofs replaced by shingle roofs, and it is rare that the old sod house is replaced by a new sod house nowadays. In nearly all cases wooden houses have taken the place of the "soddies" when they became uninhabitable. When first traveling over the country in 1900, we found very few who were intending to stay in the coun-

try. Each year we have traveled, we have found more people who were improving their places and deciding to stay and make real homes for themselves. The result is that permanent improvements are taking the places of temporary makeshifts which were put up to last until the owners could get away. And now, not so many places have the "I want to sell out" appearance once so characteristic of nearly all.

Near Vernon and Wray, the farmers are becoming comfortably fixed. Many of them are connected with each other by telephones. Once last summer while staying over night at one of the farms an orchestra was called up and all on the line enjoyed a very entertaining concert. This may surprise some who think of the whole country as but little better than a desert.

CULTURE.

The practice of the most successful farmers is to plant all crops which are cultivated during growth with a lister. The harrow is often used in cultivating until the plants are so large that it would break them if used. Gang weed cutters are used by many for cultivating listed corn after it is too large to be cultivated with a harrow. The ordinary shovel cultivator is used for the last cultivation. Some are listing their ground east and west in the fall and listing again in the spring. The fall listing is done in order to catch the winter moisture. The method of culture which is most successful is the one by which a soil mulch is maintained throughout the growing season so as to prevents excessive evaporation. Very few men prepare ground for wheat with turning plows. The cultivators and disk harrows have been found more satisfactory in preparing ground for wheat. One man claims good gains in yield by listing his ground east and west in the fall and discing in the spring. Sorghum is sometimes sown, but is much surer to produce a crop if it is planted with a lister and cultivated. It has been found that much of the winter moisture can be saved for the crop by discing the land in March. Sometimes this will save a crop. Wheat following corn is now giving the best returns in wheat seed. Wheat sown between March 1st and March 15th seems to give the better average yields than later or earlier sowing.

CONCLUSIONS.

1. The country is improving rapidly.

2. The sod house is disappearing. In a few years "soddies" are likely to be rare, except on newly settled places.

3. When prices of cattle are low, the "dual-purpose" cow is likely to become prominent, and creameries and cheese factories will receive support from the owners of small herds.

4. The production of winter eggs should be a good business on the plains.

5. If the country continues to settle up, in a short time all stock must be fed and sheltered during winter.

6. The stock industry is in a transition stage. Unless methods change, a herd of more than 300 cattle owned by one person will soon be rare.

7. Sorghum is rapidly gaining ground as a forage crop, because it is one of the surest crops known where droughts are common.

8. The number of acres it takes to sustain a cow is estimated at from ten to thirty. With a large area of carefully selected land in drought resistant forage crops the number of animals which could be kept in the country could be increased considerably.

9. The Vernon and Idalia divides, especially the Vernon divide, must be considered as farming districts. These communities raise grain for sale practically every year, and they can be depended upon for supplies of winter feed for cattle which graze in the thinly settled neighborhoods in the summer. Many farmers near Vernon now take cattle to winter, and the evidence indicates an increase in this business in the future.

10. In all districts except the Vernon divide and some parts of the Idalia divide, it will probably pay best to confine the farming to raising rough feed for wintering stock.

11. Stock raising must be the basis of all successful agricultural efforts in this region, and crop raising should be generally attempted as an aid to stock raising.

12. Each home can have a few trees, which can be kept in good condition by using the waste water.

13. Some men will fail on the Plains; but we must consider that success or failure everywhere depends upon the man behind the business.

Bulletin 78. **February, 1903.**

The Agricultural Experiment Station

OF THE

Colorado Agricultural College.

THE TOMATO INDUSTRY OF THE ARKANSAS VALLEY.

—BY—

H. H. GRIFFIN.

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THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

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THE TOMATO INDUSTRY IN THE ARKANSAS VALLEY.

BY H. H. GRIFFIN.

There are five factories in the valley devoted almost exclusively to canning the tomato. A successful pack for them means a considerable revenue to the farmers. The production of this crop has not been attended with uniform success. To get the best results has been a perplexing question, both to the farmers and to the factory operators. Poor success with this crop cannot be ascribed to diseases or insect pests, for neither caused any serious loss.

One complaint has been that the vines would grow large but fail to set fruit in sufficient quantity. Another, and more prevalent one, was that the vines would be well filled with fruit but too late to mature before injurious frosts. Most of the time the result has been that the major portion of the growers were disappointed in the returns from the crop, and the factories have been without a sufficient supply to operate profitably.

The writer was of the opinion that the troubles of the tomato growers were not entirely due to difficulties of soil or climate, but rather to the lack of a well defined system of propagation and cultivation.

To throw some light on this subject a systematic study of this crop was begun and the results of three years work are embodied in this bulletin.

The tomato is a native of tropical America where it was cultivated by the natives before the continent was discovered. For many years it was cultivated in this country and in Europe as an ornamental plant. It was considered poisonous, and went by the name of "Love Apple." It began to be used for food in some places about the beginning of the last century, but as late as 1832 it was considered a curiosity in New England. The value of the crop in the United States is now several millions of dollars annually. Tomatoes are now put on the

market in many forms and are considered an indispensible article of diet. About 300,000 acres are devoted to the growth of this crop in the United States, and the pack averages about 5,500,000 cases.

Productiveness of the tomato in the northern states, is largely a question of early bearing;—this is especially true at our altitude, where the season is comparatively short. The plant will outlive the seasons of the north, hence its life is determined by the contingencies of frost rather than by any inherent limit of duration. It does not mature at our altitude and it would probably continue to bear for some months if not frosted. It is apparent that all advantage possible must be taken of that portion of the season most favorable for its fruiting. That the lack of success in the Arkansas valley is not altogether a matter of seasonal difficulties is evident when we compare results with those in northern Colorado, one thousand feet higher, where the canneries are uniformly successful. In some parts of this district the yield averaged fourteen tons per acre in 1901. The product was so large that the canneries were unable to handle the acreage contracted.

I have ample reason to believe that aridity is an important factor in determining the yield of this crop. And another factor, no doubt, is the prevalence of strong winds or dashing rains at the period when the plant is blooming profusely.

Dropping of the bloom is quite a familiar occurrence. Often whole clusters drop, leaving not a single flower to produce fruit. As the tomato is a native of a warm, moist climate, it is apparent that dry, windy conditions, followed by cold nights, are not favorable to the pollenization of the flower and the setting of the fruit. For this reason every possible advantage must be taken of the growing season, so that if the bloom fails to set at one period there will be ample time to secure good results later. This principle is often well illustrated with the cantaloupe; a crop which there can be no doubt is adapted to this section. Cold, windy conditions may prevent the pollenization of the flowers for a short period and the result is that the fruit fails to set. This will be noticeable during the growing period. The yield is lessened thereby, and is especially noticeable if the plants are rather late ones so that the shortage may not be made up by later favorable conditions. It is reasonable to assume that the same condition holds true with the tomato.

It is common practice to plant the tomato on impoverished land or on land quite sandy, where it would not be expected to get good returns from most other crops. The opinion seems to be wide spread that a well enriched soil is positively detrimental to the tomato.

Tomatoes yielding six tons per acre will take from the soil 25 lbs. of potash, 18 lbs. of nitrogen and 8 lbs. of phosphoric acid. The vines will require 34 lbs., 28 lbs. and 4 lbs. respectively. A crop of tomatoes removes twice as much potash and over fifty per cent. more nitrogen than either a crop of Irish or sweet potatoes. Thus we see that the tomato, contrary to opinion, is a gross feeder. It may appear as composed mostly of water but there is an immense seed production that demands considerable fertility.

Prof. Bailey, of New York, after experimenting with fertilizers for this crop a number of years has the following to say:

"It is a common belief that the tomato, unlike most plants, is not benefitted by rich soil or heavy manuring. Our tests give uniformly heavier yields in heavily fertilized land. There is some reason for the widespread belief to the contrary. Much may depend upon the soil and still more upon the character of the fertilizer. It should be one quickly available to the plant. Fertilizers that give up their substance late in the season give poor results because they delay fruitfulness.

Prof. Earle, of Alabama, says there are but few soils in that state rich enough to grow satisfactory crops of tomatoes without fertilization. The following conclusions are drawn from careful experiments in New Jersey.

"That nitrogen is an important element in growing tomatoes. With sand, the increase in the use of nitrate is nearly five times that with minerals only. That a full supply of nitrogen is more effective on a sandy than on a clay soil."

Growers of tomatoes in Mississippi use on fairly good land, 400 lbs. of cotton seed meal, 400 lbs. of acid phosphate and 100 lbs. of Kainit per acre.

All of the above places have conditions naturally more congenial to the tomato than are our conditions. The season is much longer, the nights warmer and yet we see how essential they consider it to push the plant forward.

EXPERIMENTS IN 1900.

The Perfection and the Stone were the varieties used in the trials. The seed was put in the hot-beds about the first of April, intending to have the plants ready to set in the open field about the 10th of May. It was not the intention to do any transplanting. The soil

was as nearly uniform in quality as possible to get. For two years the greater portion of it had been fallow, the remainder in bluegrass. No fertilizer was used.

May 8th, two rows, (one of each variety,) 140 feet long were planted to the seed in open field. May 9th and 10th ten rows, (five of each variety) were set with plants from the hotbed. They were to receive treatment as follows: One row to be pruned while the plants were small; one after the plants were well advanced. The plants in another row were to be transplanted after growing sometime in the field. Two rows were to be grown according to usual practice as a check upon the results. The plants used in this work were of medium size, taken from the original bed; the kind of plants that are commonly set in this valley. May 28th, one row of each variety, was set with the same class of plants for a comparison of late planting.

We thus had the following questions under consideration:

1. Plants started in the open field compared with plants set from the hotbed.
2. The effect of early trimming.
3. The effect of late trimming.
4. The effect of transplanting after growing for a time in the field—whether or not it would retard growth and hasten ripening.
5. Plants set late in May compared with those set early in the month.

The early pruning was done June 19th, 28th and July 9th. The late pruning was done August 9th and consisted of a shortening in of the side shoots and tops of the vines.

The Perfection gave the first ripe fruit Augusc 9th, from one of the check rows. The first ripe fruit was taken from the Stone and from the check row August 24th.

The plants of the Perfection, set in field May 28th, did not ripen fruit until September 3rd. The other plantings, except seed in the field, were yielding considerable fruit by the first of September.

The following table gives the yield per hill of each row:

	Perfection. Lbs. per hill.	Stone. Lbs. per hill.
Seed in field	2.6	1.5
Early pruning	3.9	3.1
Late pruning	4.4	3.3
Field transplanting	4.7	3.2
Late setting	3.0	1.4
Check row	4.2	2.7

A yield of six tons per acre is represented by about 4.5 lbs.per hill.

The Stone did not bear much until the first week in September. All of the plantings were then yielding ripe fruit except that made May 28th, which did not bear until September 18th.

It should be noticed how uniform was the yield from all the plantings made early in May. The plants set late in May yielded about the same and commenced to bear about the same time as the plants grown from seed.

I had under observation one field in which considerable pruning had been done, but there was no benefit derived.

The work of the season was intended to be largely of a preliminary nature, the press of other work not enabling us to take up the question extensively. It should be noticed that the work was to test whether those ideas popularly held were true, i. e.—that the plants grew too much to vine at the expense of fruit.

From the results of the year it was quite evident to me that a lessening of the vine was of no benefit. It was also evident that late set plants were of but little value.

SEASON OF 1901.

The work of this year was along different lines from those of the preceding year.

It embraced two distinct lines. 1. Experimenting along certain lines at the station. 2. Observations, among the growers, of the methods employed and the success obtained.

The work of the station was planned as follows: (*a*) A comparison of different classes of plants, also a comparison of the time of setting in open field as affecting maturity and production. This included the use of transplanted plants (very stocky,) set early in open field. Also plants, not transplanted, set in open field early and late, and plants produced from seed sown in open field. (*b*) The yield and maturity of plants compared when grown on land heavily manured, (barnyard manure well rotted,) with land having no fertilizer. (*c*) Variety tests. The work was badly handicapped by a hail storm on the 24th dav of July. For a time it seemed as though the results for the season would be destroyed. Owing to the effects of the storm, only general results can be given, but the facts are sufficiently clear to warrant the conclusions, verified as they are by the results of others.

The seed of a Beauty tomato was sown in hotbed March 2nd, and plants from this sowing transplanted to

another bed April 13th. Seed was again put in hotbed the last of March to get plants for later setting.

April 19th, a planting of seed was made in open field. Irrigation was at once employed to germinate the seed and the plants were showing by the 30th of the month. It is not often safe to have plants in open field as early as this. This planting was made on land well enriched with barnyard manure.

April 24th, twenty very early plants were set in open field on the same land as above. They were large, lengthy plants, what might be called "leggy." May 7th and 8th a considerable planting was made of plants from the hotbed. It consisted of transplanted plants (strong and stocky,) set on heavily manured land. The same kind of plants were also set on land having no fertilizer. Untransplanted plants were also set on both the fertilized and unfertilized land. Thus on the manured land were four classes of plants. May 3rd, a planting of seed was made on unfertilized land.

May 8th, on unfertilized land, some very small plants (smaller than those above mentioned) were set, and on the 16th of May, still another planting was made. About one acre of land was used in these trials.

By June 15th the bloom was plentiful and small tomatoes had formed on the transplanted plants growing on the manured land. By the middle of June all of the plants on the manured land were blooming well, but those on unfertilized land contained but few blossoms. The first fruit was picked July 16th from the transplanted plants growing on the manured land.

At the time of the hail, July 24th, all of the plants, except those set May 16th, and those grown from seed planted May 3rd, had set some fruit. Much the best set being on the transplanted vines on manured land.

The first ripe fruit from the plants grown from seed on manured land was picked July 29th. This was about two weeks later than from transplanted plants. It was August 23rd before any ripe fruit was taken from the plants set the 16th of May, more than a month later than the first ripening. The last of August the plants on the manured land were yielding fully twice as much fruit as those on unfertilized land. The early plants were yielding much better than the late ones.

It was the middle of September before fruit in any quantity was taken from the plants grown from seed planted May 3rd, or from the planting of May 16th. Just

what effect the hail may have had upon the various dates of ripening cannot be told. The total yield of perfect fruit was light. It was the intention to have a record of each planting, but it was found it would reveal nothing owing to the injury of so much fruit by hail.

Close observation was kept of some tomato fields, especially of such as were apt to give some data along the lines we were studying.

March 3rd, Mr. J. H. Crowley put tomato seed in hotbed and transplanted to boxes in another bed April 2nd. These boxes were made of building paper by cutting the desired size, folding and tying with a string. The boxes were left on the plants when they were put in the field. The plants were set in open field May 14th, at which time they were more than a foot in height and blooming some. Part of them were put on land that had been fertilized with nine loads of sheep manure per acre. The other portion was put on the same kind of soil but having no fertilizer. The first ripe fruit was taken from the vines on manured land July 4th, about three weeks earlier than the others. Mr. Crowley estimates the yield from the manured land as being about 60 per cent. the greater. Wherever the manure was applied there was an immense benefit, apparent in the size of the vine and the amount of fruit.

Messrs. Fullmer and Sanders had about four acres of tomatoes on alfalfa sod. They made their first planting in open field about May 10th. Some of the plants were potted but the greater portion were from the original bed. The first ripe fruit was taken July 8th, from the potted plants.

The last week in May another portion of the field was set with plants from the original bed. From this planting the first ripe fruit was picked the first week in September. There was a difference of only three weeks in the time of putting the plants in the field, yet there was seven weeks difference in the period of ripening. The early planting yielded heavily and by the first of October was still yielding as well as the later planting. Thus we see the tomato will bear a long time if the ertility is present to support the plant.

From the field about 40 tons of fruit was sold, 34 tons going to the cannery. It was estimated that the yield from the first setting was 12 tons per acre, and from the late setting 8 tons per acre.

The last picking was made October 20th, at which

time there were immense quantities of green fruit on the plants set late in May. If frost had come as early as usual these plants would not have made the returns they did. This is quite a striking example of the benefit to be derived from the use of strong, early plants. This was the finest field of tomatoes I had yet seen in the valley. If it were true that a heavy nitrogenous fertilizing would produce vine at the expense of fruit, we would expect to see such results in this instance. On the contrary, we find this field yielding double, and often treble, what many other fields did in the vicinity.

Another striking example of the benefit derived from the use of manure was on the farm of Mr. Foster, Manzanola. His land is quite sandy, consequently it gets very hot during the summer. Part of his tomato land had been manured quite heavily. The same class of plants were used throughout and the planting was done at the same time. The plants on the manured land grew large and thrifty and made a good yield. Those on unfertilized land were small, unthrifty and many blighted. The yield was not sufficient to warrant the labor expended.

SEASON OF 1902.

This was largely a continuation of the work of 1901. However, more time was given to observing the work of different growers, especially in the vicinity of Manzanola. Mr. Barton, of the Manzanola Canning Co., was much interested in the effort to improve the industry and extended many courtesies.

The work on the station land comprised the following:

1. **Comparison of plants grown in the field with those from the hotbed.**
2. **Comparing transplanted plants with those not transplanted.**
3. **Comparison of land well fertilized with land not fertilized.**
4. **Comparison of early and late plants.**

April 26th, seed was sown in open field on land heavily manured with rotted barnyard manure. Speedy germination was secured. Adjoining these were set, on May 7th, thirty-five long spindling plants taken from the original bed. They were from a bed made early in March. Adjoining these were set, on the same date, seventy plants taken from the same bed but which had been transplanted a short time. There was but little difference in the appearance of the plants from the two sources. The plants were purchased for the purpose of making the comparison. Next to the above were set transplanted plants that were of nice size, strong and stocky. They

were from a bed made early in March and transplanted to another bed about the middle of April. Some plants of medium size, considered of medium quality, were taken from the original bed and set at the same time (on manured land) as those above mentioned. The latter class of plants were also put on adjoining land that had not been fertilized. The plantings to this time comprised 27,160 square feet of land.

May 14th, we set in open field some small transplanted plants together with some from the original bed. These were small plants but as good as many that are used every year by those growing for canneries. May 26th, another planting was made with plants from the original bed. These plantings were made on land that had received no fertilizer for years and comprised six-tenths of an acre.

After the setting of the plants, irrigation was given two or three times until the plants were well established, after which they were thoroughly cultivated and hoed. The next irrigation was June 18th. It was again irrigated commencing July 15th, and the water was last applied the 20th of August.

The first ripe fruit was taken July 25th from the stocky transplanted vines set on the 7th of May. In a few days the purchased plants and the larger ones from the original bed were also ripening fruit.

August 10th, 13 lbs. of ripe fruit were picked from the former vines, on the 20th, 54 lbs. were picked and on the 22nd, 137 lbs. From this time this class of plants were yielding in such quantity as to warrant picking and delivering to a canning factory. The plants put in the field May 14th were not setting fruit until the last week of July, at about the same time the transplanted plants on manured land were ripening fruit.

The first to ripen of the May 14th planting was the transplanted vines, August 25th. The plants put out May 26th did not ripen fruit until the first week of September.

August 25th a few ripe tomatoes were taken from the plants grown from seed (planting of April 26th.) As in 1901, plants grown in this way ripened their fruit about the same time and yielded about the same as late plants from the hotbed. If the season is favorable and the conditions are such as to push the plant, ripe fruit can be secured in time to get fair returns. The fruit picked from the vines set on May 7th amounted to 7,487 lbs. or, at the rate of about six tons per acre. The greater portion was picked

before frost became severe enough to seriously injure the fruit. The yield would have been larger had the seed been true to name. It was purchased for the Beauty but the product resembled the Acme more.

The equal area set May 14th, yielded only 2,550 lbs., or, at the rate of 4,250 lbs. per acre. The difference in the yield of the two plats can be attributed to the difference in fertility, the class of plants used and the time at which they were set. It can be attributed mostly to the first two causes, as there was a difference of only one week in the planting, but nearly a month in the time of ripening. The greater portion of the yield was secured after severe frost and the fruit was more or less injured. The results are in harmony with those secured by other growers.

A factory with a considerable acreage, similar to the early ones, could begin to pack by the 20th of August. September would be well advanced before packing could commence if the acreage corresponded to the last can. The tonnage would not be sufficient nor the quality satisfactory. The grower becomes discouraged and is slow to again venture in the business, preferring to put his land to some crop in which the returns are greater and surer.

THE FIELD OPERATIONS.

It is difficult to draw conclusions from this work for the reason that in but few cases can comparisons be drawn. The class of plants used, the kind of soil, the time of setting, attention given, and fertilizer used, seldom enable any comparisons to be drawn. Hence it is difficult to get very much reliable information from a vast amount of this kind of work. One little experiment where the conditions are under control is apt to be worth much more than the observation of many conditions of which we know but little.

Probably the best crop of tomatoes grown in the valley this year was that of Mr. H. W. Harlow, near Manzanola. From 1¼ acres he took 18 tons of tomatoes. The soil on which the crop was grown had supported cottonwood trees until two years previous. The location was in a swale, the soil naturally quite rich and enriched by the addition of much vegetable matter from the tree leaves, etc. The land was fall plowed dry, turning up in large prices. The planting was done about the middle of May with plants from the original bed, the plants were of good size, thrifty and forced from the start. Mr. Har-

low states that he replanted some missing hills in June but at picking time could discern no difference. This, I think can be accounted for from the fact that the vines were extremely large, very closely planted together and difficult to tell one plant from another. The rows were four feet apart and the plants 3½ feet in the row. One plant occupied about 14 square feet of land, hence an acre contained about one-third more plants than are ordinarily grown. The fruit was a very fine specimen of Beauty, which augmented the yield. A portion of the plants were from seed saved by Mr. Harlow. The vines were so large and so thickly covered the land that the first frosts did them but little injury, in fact, rather aided the ripening. The first delivery to the factory was made August 27th, but the heaviest yield was from October 11th to 23rd. Thus it is seen that the field was not an early one, which could not be expected from the class of plants used. The conditions in this field are such that no comparisons can be drawn, but it is of interest by reason of results secured.

The field that gave the most promise early in the season was one of about 14 acres, most of which was alfalfa sod. Many of the plants used were grown as follows: The seed was put in hotbed the middle of February and transplanted to a muslin covered bed with under heat (manure) in March. The tops were clipped to make the plants stocky. They were set in open field about May 10th; strong and stocky with a splendid root system. Some of the plants from the original bed were also put on the alfalfa sod. These were also good plants with good root systems. On some cultivated land near by some of the late plants were set; small, weak plants compared with the others. Owing to the scarcity of water, this field could not get the desired attention. It was in an exposed location and a severe wind about July 20th, did it much damage. At this time all of the plants on the alfalfa sod were large and thrifty and appeared to be well set with fruit. The late plants were small and no fruit had set. On August 16th I took particular note of the amount of fruit on the transplanted vines and those not transplanted, both on alfalfa sod. It was estimated the former were supporting nearly twice as much fruit as the latter. Ripe tomatoes were picked from this field August 1st. About the 16th of the month from 150 to 200 lbs. was being picked every other day. Delivery to a factory could have commenced by August 20th. As heavy

returns were being made to the factory during the last week of September, as at any time during the season. It was one of a few fields to make its heaviest returns prior to October 1st.

This field suffered for water the whole season, but especially during the latter part of July when water was demanded the most. It can be truly said that the scarcity of water was responsible for the light yield which this field gave. The late set plants gave no returns. The comparison that could be made here showed the superiority of the transplanted plants.

Another field, to which particular attention was given, was one of about three acres on very sandy land. About two-thirds of it had been manured with unrotted sheep manure. The plants were from the original bed and of fair size, set in open field about May 20th. There was a portion of the field set about two weeks later than the above. About July 20th the early plants on the manured land had considerable fruit of good size and it was still setting. The plants set later were much smaller and were just commencing to form the fruit. By the last week in August the vines on the manured land were large and thrifty, well set with fruit. They had been yielding some ripe fruit for nearly a month. Delivery to the factory was made at the time of opening, August 25th. The yield was 30,194 lbs. besides much shipped to market. The heaviest deliveries were made about September 20th. The vines on the unfertilized land gave much tne lighter yield and were about three weeks later ripening. Water was used in abundance but this was made necessary by so much dry heating material in the soil. As an instance of what early planting and good plants will do, we record the following: The above grower had a few good plants set in the garden in April and protected for a time from frosts and winds. These plants ripened fruit July 20th and bore well for the season.

Special mention might be made of many fields but it will suffice to give a general account of results. In nearly every instance when small plants were set rather late in open field, and especially on land given no special preparation, fruit formation did not commence until about July 20th. From observation made this season it is found that the time required to ripen the fruit after formation is from forty to fifty days. This was true of the first fruit that formed. If the forming of the fruit is delayed until the 20th of July there will be none ripe before the first of

September and the greater portion of it will not ripen until about October 1st. It can be readily seen what an advantage there is in having the fruit ripening by the last of July. It means that the heaviest deliveries can be made about the middle of September, before frost does serious injury to the tomato, thus insuring a good uniform pack with much less loss than in the late one.

After the middle of September, the nights begin to get quite cool and usually the tomato ripens slowly.

The results as a whole indicate that soil conditions play considerable part in tomato growing. The tomato seems to prefer a virgin soil, and a sandy soil is preferable to a clay. Considerable adobe is not desirable.

Increase in vigor and productiveness evidently are closely associated with careful handling and good tillage. There can be no question that transplanting, properly done is invaluable. *Stocky plants*, vigorous and growing well *are better* than simply early plants. This was plainly shown in our tests of 1902. On the other hand, transplanting does not avail anything over early plants well grown unless the transplanting is done a sufficient time to increase the root system of the plant, together with its strength and general vigor.

Good healthy plants started medium early and kept growing vigorously are preferable to early plants allowed to get too thick in the bed, which causes them to become spindling and stunted in their growth. They are also preferable to a transplanted plant that has been stunted. A good tomato plant, at time of setting in the field, is one which is stocky enough to hold the weight of itself, together with a considerable amount of dirt, about the diameter of a lead pencil and 6 to 8 inches in height. A tall, weak plant is not worth setting. The desirable thing to secure in this country of short seasons and cool nights is a plant having age. It stands to reason that the older the plant the sooner it will commence to bear—it takes about so long for a plant to come to the bearing age. The most successful way to accomplish this is by transplanting. If this is not done care should be exercised that the plants do not become crowded and "leggy" before time of setting.

We must bear in mind that the tomato will not give profitable returns without more care in the selection of seed, plants and soil than is given most of our staple crops. Special preparation must be made for the crop. A small acreage grown under the most favorable conditions is

worth more than many times the same amount put in and tended in a haphazard way.

VARIETIES.

During the season of 1901 the writer had under trial or observation with different growers the following varieties: Magnus, Success, Burpee's Combination, Enormous, New Large Early, Fordhook First, Fordhook Fancy, Quarter Century, Acme, Tall Queen, Ruby, Dwarf Champion, Kansas Standard, Perfection, Matchless, Truckers' Favorite and Beauty. Of this list there are but few that seem to have any merit for this country. For canning purposes, where it is necessary to combine earliness, appearance, quality and productiveness, the Beauty easily takes the lead. The factories recommend this variety. It is also a splendid shipper. The Acme is a little earlier and for early shipping to markets may be preferred to the Beauty. The Fordhook First is also a good early shipper. During the past season there was much loss occasioned by the failure of plants to bear fruit typical of the Beauty. It was a great disappointment to have the yield so materially reduced and it was a source of loss both to canner and grower. Seed selection has never been given proper attention by the growers and it is one reason why success is not oftener obtained. The tomato is one of the most variable and inconstant of garden plants. Authorities say that varieties of tomatoes as a rule are short lived and that ten years may be considered the profitable life of a variety. Many of us are aware that old standard sorts are now extinct.

To illustrate this I wish to quote from Bulletin 32, Bailey & Lodeman, (October 1891) of the New York Experiment station, under the heading of "Do varieties of tomatoes run out," it has the following:

"For some years it has been apparent to the writer that varieties of tomatoes run out or lose their distinguishing characters. The reasons for this loss of varietal character are not necessary now to discuss. Crossing, no doubt hastens it in many cases. But it is well to state that running out does not mean deterioration simply, but disappearance of characters by whatever cause. Studies of this question were made this year by growing the same variety from many seedmen. This gave us an opportunity to determine if the variety had varied greatly in the course of its history, or if all seedmen really sold the same thing under a given name. In order to determine how long a variety may persist, we selected Grant and Canada Victor, which are old varieties; and to find how soon a variety may depart from its type we grew the Ignotum."

"Grant was obtained from seven seedsmen,—all who catalogued it. Of these seven samples, but two were true Grant as the variety was recognized years ago. The remaining five samples grew fruits

of various kinds, although somewhat resembling the Grant type. It may be said that these variations were due simply to mixing of the seeds during a number of years by careless handling, but there is reason to suppose such is not the case. The Grant has a peculiar small, slightly curled, light colored foliage and a well marked upward habit of growth of the young shoots. These characters appeared constantly in all the samples. The foliage, being less variable than the fruit and not an object of selection by the horticulturist, had remained constant, while the fruit had lost its character."

"Canada Victor was grown from ten seedsmen. There were none which could be recognized as true Canada Victor, but they were all small, variable, irregular and practically worthless. Yet in all the samples, the peculiar, slightly curled foliage of the Canada Victor was apparent."

"Ignotum was obtained from fifteen dealers. This variety was first offered by seedsmen in 1890. Of the fifteen samples, eight gave small and poor fruits, which were not worth growing and could not be recognized as Ignotum by any character. The other samples were fairly uniform and represented a medium type of Ignotum.

"Ignotum grown from one of our own savings gave a number of plants which bore inferior fruits, although clearly Ignotum. It is difficult to suppose that in one season a variety could so far have lost its characters that one-half the seedsmen should offer inferior stock of it. The variety is well fixed, for in one of our large plantations of it, it was remarkably uniform and equally as good if not even better than two years ago."

DISTANCE TO PLANT.

The vines should be sufficiently close to shade the ground during a portion of July and August. The heat and reflection of the sun from our light colored soils often have an injurious effect upon the tomato plant. On well fertilized land I would recommend that the plants be set about 4 feet each way. That it is none too close we have good evidence in the field of Mr. Harlow, previously noted. His plants were even closer than this and yet he got more fruit on one acre than many secured on four acres.

The sun and heat evidently cause physiological troubles, which growers often include under name of blight. A familiar trouble of this kind is a blackened condition of the plant, or portion of it, late in the season. This is quite prevalent on light, sandy soils where the plants are small and exposed.

The trouble first manifests itself on the south-west side of the plant. I have never seen it when the plants were large and covered the ground. The plants have been examined for fungi and bactria by competent persons but none have been found present. It seems to be physiological trouble caused by excessive heat. Blistering of the fruit is quite a common occurrence when it is exposed and is often a source of considerable loss. It

well illustrates what a powerful effect the sun has upon exposed vegetation.

Another disease is sometimes present which is commonly termed blight. It has been described as caused by bacteria and very much resembles the field or southern tomato blight. It first manifests itself by the top leaves folding together and turning yellow. It gradually destroys the leaves downward, the first affected leaves dying. Finally the stem turns yellow and the plant slowly succumbs. Exposure to the reflection of the sun's rays from light colored soils seems to favor its development. This was well illustrated in 1901, where a grower had trained about one dozen vines to stakes and kept them pruned up high according to the practice in the southern states. Every one of these plants were destroyed by this disease and much of the fruit that formed was blistered. By the side of these plants about one-eighth of an acre of tomatoes were set out at the same time but which had grown sufficiently rank to cover the ground. There was no sign of the disease on these plants, the fruit was not injured and the yield was good. This disease was reported by the writer in New Mexico bulletin No. 21. It was found there that the disease was much worse on the light sandy soils than on the dark colored bottom lands.

The fruit of the tomato is occasionly affected by what is commonly termed blossom end rot. This is a blackened condition of the blossom end which gradually enlarges until the tomato is destroyed. There is no efficient remedy known. It is possible that a too free use of irrigation water late in the season may increase it.

IRRIGATION.

The tomato does not require an abundance of water but it requires a constant and uniform supply. The most water should be applied when the fruit is forming, when the vines are in bloom quite well. As soon as the plants have become established, only sufficient water should be given to keep them growing nicely. This is the time the cultivator and hoe are demanded. The growth of the tomato is of a succulent nature and should not be forced too much by a plentiful supply of water in its early stages. The result of so doing will be a tender growth of a yellowish color instead of a healthy green, forming wood instead of fruit buds. If the water is withheld until the bloom is well started, a plentiful supply will aid the setting and growth of the fruit. However, it should not be

applied too late, as after the nights become cool watering may retard the ripening.

In the Holbrook country this season were some good illustrations of the drouth resisting power of the tomato. The last of August I saw large thrifty vines that had been watered but twice, once at the time of putting in the field and again the first week in August. Where the best results were secured the land was very retentive of moisture, as was also the subsoil, which furnished a small but constant supply. Some of these fields gave promise of ripe fruit by early September, yet tomatoes were not marketed in quantity until about October 20th.

INSECTS.

There are two common insects which trouble this crop every year, viz: the tomato worm, (*Protoparce celems*) and the corn or boll worm, (*Heliothis armigera.*) The former is very easily controlled by spraying, yet it is surprising how few growers utilize any means of this kind, but will put in much time destroying the worm by hand. Any of the poisons as commonly used for spraying apple trees will be effective against this worm. The best material to use is the arsenate of lead for it will not injure foliage, no matter in what strength used.

The latter is the larva of a night flying moth. There is no very successful way known of controlling this insect. It is sometimes recommended to plant sweet corn near the tomatoes as a trap crop. We tried this remedy this year with considerable success. It can be said that those growing near the corn were nearly free from worms, while those at a distance were injured to a considerable extent. Three successive plantings of corn should be made, the first at the time the tomatoes are set. Each planting should be disposed of before the worms get large enough to leave the ears. The Hazeltine moth trap was tried during the season of 1901 to note if the extent of injury could be reduced by this means. The trap was set two or three nights in a week and the catch sent to Prof. Gillette for determination. We failed to catch a corn worm moth during the season.

THE SAVING OF SEED.

A few instances have come under my observation where splendid success was obtained from the use of home grown seed. The fruit was large and typical of the

variety. A portion of the crop grown by Mr. Harlow was from seed of his own saving. Too often purchased seed is not what it is recommended; it may be (for all the purchaser is aware) the refuse from canning factories. It would seem the wise thing for our growers to save their seed from perfect specimens.

PROPAGATION OF THE PLANTS.

Every grower of tomatoes should be prepared to grow his own plants and these of the finest quality. By so doing he has the plants at hand to put in the field, without any deterioration in quality, when the soil is ready and the water at hand. To get the best results, the soil for the bed should be prepared by composting. It is not essential that glass should be used, but it is preferable for starting early plants. Canvass requires considerable more care and labor in affording additional protection. Furthermore, it requires considerable more bottom heat as there is not so much heat secured from the sun. In times of bad weather too much shade may be the result with canvass, causing the plants to grow too spindling.

When plants are started in February or early March, glass should be used. Before they become large enough to crowd (in early April) they may be shifted to a canvass covered bed.

CONCLUSIONS.

1. Some good crops have been grown every year and if proper methods are employed good results may be secured by a large majority of the growers every year.
2. Seed of known quality must be used.
3. Proper selection of varieties is essential.
4. The plants must be started early so as to give them age, strength and a good root system.
5. The plants should be thrifty and set in open field as early as frost will permit.
6. Sandy or loamy soil is preferable but it should be well fertilized with some quick acting fertilizer; that a virgin soil and alfalfa sod give good results.
7. A constant and uniform supply of moisture, but not too abundant until the blooming period is well started.
8. Close planting that the ground may be shaded to avoid injury to vine and fruit.
9. The tomato is a valuable crop with which to subdue alfalfa for succeeding crops.
10. The crop should be ready for canning fully three weeks earlier than has been the custom, thus insuring profit to the grower and the packer.

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The Agricultural Experiment Station

OF THE

Colorado Agricultural College.

TREATMENT OF STINKING SMUT IN WHEAT.

—BY—

JOSEPH REED.

PUBLISHED BY THE EXPERIMENT STATION
Fort Collins, Colorado.
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TREATMENT OF STINKING SMUT IN WHEAT.

BY JOSEPH REED. *

INTRODUCTION.

It is not the purpose of this paper to present anything new in the way of preventing smut in wheat. Many remedies have been tried, some of them giving very good results, others giving poor results, and in some cases the germinating power of the grain was destroyed. While the practice of treating seed wheat for the prevention of stinking smut is quite general in many localities, yet from the many inquiries that come to the Experiment Station in regard to smutted wheat it is evident that the treatment is not understood by all. Some growers try a good remedy but fail to obtain good results because they neglect an important detail. Others treat their seed one year with good results while the next year the same treatment may prove a failure. Such an experience is likely to discourage further effort to combat the disease. But it is safe to say that failure is always due to the remedy being improperly made or applied. The evident good results the first year may have been due to a small amount of diseased seed rather than to the treatment. The second year the disease was still unchecked by the inefficient remedy, and increased enough to cause considerable loss.

A small amount of smut in grain cannot be readily detected. Many people conclude, therefore, that their seed is free from disease and so dispense with the treatment. Many times a crop can be grown without treatment, but on the other hand a better crop might have been produced from treated seed. At any rate the farmer who treats his seed is not running any risk; he has a cheap insurance.

Before starting these experiments all available literature on the treatment of wheat for the prevention of smut

* A Senior Student in the Agricultural College. The experiments were carried on with the advice and under the direction of Professor Paddock.

was consulted. It was found that a great number of remedies have been tried, but it was hard to decide which was best. The object then in view was to obtain the best remedy that was cheap and easy to use. Many experiments have been performed with the hot water treatment. This is a good remedy but it is inconvenient to use; the water must be at just such a temperature, if below 130 F, it will not kill the smut, if above 140 F, it destroys the germinating power of the grain. Taking into account the heating of the water, the cost of this treatment is about as great as other remedies which give good results and which are much easier to use.

Smut seems to be worse some years than others. Some experimenters say that this is because of the amount of moisture in the soil, some years being so dry that all the smut spores cannot germinate. Varying amounts of moisture probably have an influence on the disease, but since the spores germinate with the grain the smut will most likely germinate if the grain does. It is of the authors' belief that variation in the amount of smut depends more upon the seed that is used. Many farmers after growing wheat free from smut a few years think it is useless to treat and consequently stop, or if they do treat, the operation is carried out very carelessly; this neglect is what gives the smut a chance, so allowing the disease to be more plentiful some years than others.

Occasional reports come to the Department from all over Colorado that smut has destroyed a whole crop of wheat, and numerous cases where the crop is badly affected. To the unobserving person this grain looks as well as any, while it is in the shock, but when the threshing time comes a large part of the supposed grain is blown on the straw pile in the form of smut spores, some of the spores lodge on the grain, and some pass out as whole kernels in which the outside covering has not been broken and is hauled off with the grain.

STINKING SMUT OF WHEAT.

(*Tilletia foeteis.*)

Stinking smut is a fungus which destroys the kernel of the wheat. This disease lives over winter in the form of spores which are microscopic in size, black in color, and globular in form. The interior of the kernel is frequently completely filled with a mass of these spores and when the outer coating is broken, as is often the case, the spores are set free and many of them lodge on the healthy grains and are held by the minute hairs which occur on the kernels at the end opposite the point of attachment.

The spores can live through very unfavorable conditions and they germinate under the same conditions as the wheat. The smut spores begin their attack as soon as the wheat grains have sprouted. The germ tubes enter the young wheat plant where they appropriate nourishment for the development of the smut plants. From this time on the two plants grow up together, the smut growing in the interior of the wheat stalk.

When the wheat stalk heads out and the kernels begin to form, the smut attacks them and absorbs the nutritive substance from the kernel. The smut then forms its seed-like spores which live over winter, and are produced only in the interior of the kernels, the glumes surrounding the kernel being unharmed. This is why smutted grain often looks healthy and well developed, but sometimes these glumes surrounding the kernel break away at the top and spread out, thus giving the head of wheat a ragged appearance. It may not be noticed that the grain contains smut until the shell of the kernel is broken and the smut spores are set free. Diseased kernels can usually be told, however, in that they are somewhat swollen and darker in color. It is known that one smutted kernel contains many thousand spores. When the grain is threshed the spores are scattered all through the grain and a crop that has but little smut one year may be nearly all smut the next year. Some grain with smut spores may fall on the ground and come up the second year as volunteer grain; this is the reason why we have smut when clean seed is planted if the same ground is seeded to wheat.

There are two kinds of smut, the Stinking Smut and Loose Smut. The Loose Smut obtains its name from the

loose-like condition which the smut is in after the spores are formed. In the loose smut the whole head of wheat is attacked, the glumes and all parts of the head are turned into a mass of smut spores which are often blown away by the wind before the grain is cut.

There are two species of Stinking Smut—*Tilletia foetens* which has the smooth spores, and *Tilletia tritici* which has spores with net-like ridges on the outer surface of the spore wall. The Stinking Smut obtains its name from its disagreeable odor, a small amount of it in the grain spoiling the flour.

THE EXTENT OF INJURY.

Stinking Smut causes more injury than is generally supposed. It has been known ever since the time of the early Greeks, but it has only been within the last ten years that very much work has been done to find a preventative. Investigations made at other Experiment Stations show that the loss may be from 1 per cent to 75 per cent of the crop. This loss is not altogether the loss of the grain, but what grain is saved can only be ground up for feed, for if it contains 15 per cent of smut it is unfit for flour. W. T. Swingle says: "There are no accurate statistics as to the amount of damage caused by these smuts. In many localities the loss is very large, and it cannot be doubted that in the whole United States it amounts to many million dollars annually."

By treating the seed every year this loss may be prevented. Smut will not appear unless the spores are planted, except what occurs on the volunteer grain, which is already in the field, caused by successive planting to wheat.

If a crop does not contain smut one year it is not a sign that the same wheat sown on the same ground will not be diseased the next year, because spores may be brought to the seed wheat by the threshing machine, or be carried by the wind and lodged on the grain. The only safe rule is to treat all seed every year. It is possible to grow a crop for several years without having smut, but in localities where it is common or where it has been and is partially stamped out, the seed should be treated every year.

METHOD OF TREATMENT.

Two methods of treatment were used in the experiment, soaking and sprinkling. The grain that was sprinkled was spread on a floor and the solution sprinkled on. The grain was shoveled over and over until all the kernels were

wet, care being taken that no more of the solution was added than was required to wet every kernel. In the soaking method the grain was placed in a tub, then the solution was added until the grain was completely covered. The mixture was stirred so every kernel came in contact with the solution and all floating kernels were removed. The grain was soaked different lengths of time, as shown in the table on page 5.

CHARACTER OF GRAIN AND SOIL.

In order to give the treatment a thorough test the worst smutted grain that could be found was used. It was so badly smutted that it had been sold for hog feed and no one would think of planting it to raise a crop of wheat. When the grain was placed in the tub to be soaked the solution was colored black by the smut spores.

The soil upon which the grain was planted raised a crop of oats the year before, and previous to that time it was used for a nursery. The soil was in very good condition to raise grain, and it certainly did not contain any smut spores.

The ground was divided into ten plats of equal size, the first and last plats were used as checks, being planted with untreated grain. All plats were seeded broadcast.

TREATMENT OF GRAIN AND RESULTS.

No. of Plats.	Treatment.	Method.	Strength of Solution.	Time.	Percent smutted Heads.
I.	Untreated				80 +
II.	Copper sulphate	Sprinkled	1 lb. to 4 gals		½ +
III.	Corrosive sublimate	Soaked	1 lb. to 50 gals	10 min.	½ +
IV.	Corrosive sublimate	Sprinkled	1 lb. to 50 gals		½ +
V.	Copper sulphate	Soaked	1 lb. to 4 gals	2 min	2 +
VI.	Formalin	Sprinkled	1 lb. to 45 gals		nearly free
VII.	Potassium sulphide	Sprinkled	1 lb. to 8 gals		75 +
VIII.	Copper sulphate	Soaked	1 lb. to 24 gals	12 hrs.	5 +
IX.	Slaked lime	Mixed	1.4 lbs. to 20 lbs		50 +
X.	Untreated				80 +

DETAILS OF EXPERIMENTS AND DISCUSSION OF RESULTS.

The grain was treated March 14, 1902. When the treatment was over, all the grain excepting that treated with slaked lime, was spread out on the floor to dry. The lime and the wheat were well mixed and then placed in a conical shaped pile until planted. Three persons carefully estimated the percent of smut in the various plats.

Plat No. 1. Was planted with untreated seed. This showed that the seed was extremely smutty as eighty per cent. of the heads were diseased.

Plat No. II, planted with grain sprinkled with copper sulphate in proportion of one pound copper sulphate to four gallons of water; this gave the solution a dark blue color. One-half of one per cent. was the result. This result is much better than could be expected from the seed used.

Plat No. III. Planted with grain soaked ten minutes in a solution of corrosive sublimate in the proportion of one pound to fifty gallons of water. This gave one-half of one per cent. of the grain diseased.

Plat No. IV. Planted with grain sprinkled with corrosive sublimate in the proportion of one pound to fifty gallons of water, this gave the results of one-half of one per cent. of the grain diseased. These results prove that sprinkling is as good a method of treating as soaking.

Plat No. V. Planted with grain soaked two minutes in a solution of copper sulphate, in proportion of one pound copper sulphate to four gallons of water, giving results of one-half of one per cent. of the grain diseased.

Plat No. VI. Planted with grain sprinkled with a solution of formalin in proportion of one pound formalin to forty-five gallons of water. Scarcely a smutted head could be found in the plat. This result not only shows that formalin is a good remedy, but it also shows that the sprinkling method can be depended upon.

Plat No. VII. Planted with grain sprinkled with a solution of potassium sulphide in proportion of one pound to eight gallons of water. This gave very poor results, seventy-five per cent. smut. The solution was probably a little weak, but the result obtained shows that it could hardly be made strong enough to be a complete prevention.

Plat No. VIII. Grain soaked 12 hours in a weak solution of copper sulphate, one pound to twenty-four gallons of water. Result five per cent. of diseased wheat.

Plat No. IX. Planted with grain mixed with slaked lime in proportion of one-fourth pound lime to twenty pounds of grain, this gave poor results, fifty per cent. smut. With the use of any more lime the grain could not be sown evenly.

Plat No. X. Planted with untreated grain, the results of eighty per cent. of the grain diseased.

SUMMARY.

I. The results obtained in these experiments are remarkable because the seed used was so badly diseased. No one would think of using such grain for seed. With ordinary seed the treatments that gave the best results, would insure a crop entirely free from smut.

II. The sprinkling method proves to be as effective as the soaking method.

III. Copper sulphate, corrosive sublimate and formalin prove to be efficient remedies.

IV. Copper sulphate in a weak solution will not do good work even when allowed to soak a long time, twelve hours for instance.

V. Potassium sulphide is a very poor remedy for smut besides being expensive.

VI. Sprinkling with copper sulphate is recommended to be the best remedy. Solution, one pound of copper sulphate to four gallons of water. It is the cheapest, the handiest to use and gives as good results as any treatment tried.

VII. The smut is planted with the grain and germinates at the same time. If the seed is free from smut then the crop will be unless volunteer grain comes up in the field.

VIII. To treat the grain by the sprinkling method, place the grain in a bin large enough so the grain can be shoveled from one side to the other. Sprinkle the solution on with a common watering pot and at the same time keep shoveling the grain over and over. When the kernels are all wet the treatment is finished, but great pains must be taken to see that the work is thoroughly done.

IX. Because the grain is clean one year do not run the risk of its being free from smut the next, but treat every year.

X. The grain should not be treated very long before it is planted because it will start growing. After treatment it should be allowed free circulation of air so that it will dry quickly.

XI. The sprinkling method is by far the quickest and easiest method. If the user does not have a floor to spread the grain out while treating, a canvass, or any large cloth can be used.

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The Agricultural Experiment Station

OF THE

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Laying Down of Peach Trees.

—BY—

WENDELL PADDOCK.

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1903.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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LAYING DOWN OF PEACH TREES.

BY WENDELL PADDOCK.

Peach growing, from a commercial standpoint in Colorado, is largely confined to the western slope of the mountains. The trees find a congenial home in many localities in several counties, consequently large areas are devoted to the cultivation of this fruit. Peaches have been extensively tested in various fruit sections east of the mountains, and in the Arkansas Valley in particular an occasional fine crop is produced. Indeed some of the best exhibits at the State Fair last fall, were grown in this section. But in four years out of five, perhaps, late spring frosts or extreme cold in winter destroy the buds. North of the Valley, peaches are rarely produced unless the trees are protected in some manner.

This experience, when success was just within reach, stimulated the growers in their efforts to overcome climatic conditions. Various devices were tried for protecting the trees during the winter and spring. These included wrapping the trees with cloth or covering with corn stalks, evergreen boughs, boards and, in fact, most anything that was at hand that might afford protection, but after several years trial, these methods were found to be of little use. In the fall of 1896, Hon. W. B. Felton, of Canon City, began experimenting with laying trees down, using two trees in this first trial. Mr. Felton was closely followed in this work by Mr. C. C. Rickard, also of Canon City, and to these two men belong the credit of working out this system of protecting trees in Colorado. And, in fact, after a rather hasty consultation of horticultural literature, I do not find any record of this method of protecting trees having been tried at an earlier date.

From this modest beginning an industry has sprung that is now assuming no mean proportions in that vicinity. A large number of fruit growers have planted peach trees varying from a few to several hundred in number. Mr. Rickard is, perhaps, still the largest grower, having now 1,000 trees in bearing.

The method of planting an orchard with the intention of laying the trees down during the winter, does not differ materially from that which is ordinarily observed. Some, however, claim that when the tree is planted the roots should be spread out on

Fig. 1. Three-year-old tree in full bloom.

Fig. 2. Mr. C. C. Rickard in his ten-year-old orchard.

either side of the tree at right angles to the direction in which it is to be laid down. Mr. Rickard pays no attention to placing the roots, claiming that in a few years the roots spread so that any evidence of training is lost. Others make a point of setting the trees close enough in the row so that when laid down the tops of one tree shall overlap the base of another. The roots are thus afforded protection as well as the tops.

The following data furnished by Mr. Rickard is given in detail as it represents the experience, not only of the largest grower, but of one who has had the longest experience in this method of growing peaches. As is true with many horticultural operations, there are different ways of doing the same thing, consequently other growers differ with these instructions in points of minor detail, but in general, the process must be the same.

Yearling trees are set in the spring and they should be laid down the first winter, repeating the process each season during the life of the tree. In this instance no attention is given to training or placing the roots. As soon as the trees have shed their leaves and the wood is well ripened, they are ready for winter quarters. This is usually in the fore part of November, in the vicinity of Canon City. The first step in the operation consists in removing the earth from a circle about four feet in diameter around the tree. When sufficient trees have been treated in this manner to make the work progress advantageously, water is turned into the hollows. After the ground has become saturated the trees are worked back and forth and the water follows the roots, loosening the soil around them so that they are pushed over in the direction that offers the least resistance. When treated in this manner the trees go over easily and with comparatively little injury to the root system. That is, providing the trees have been laid down each year. It is difficult to handle old trees in this manner that have never been laid down, and usually it will not pay to try.

After the trees are on the ground, further work should be delayed until the ground has dried sufficiently to admit of ease in walking, and in the handling of the dirt. The limbs may now be brought together with a cord, and so lessen the work of covering.

After experimenting with many kinds of coverings, burlap held in place with earth has proved the most satisfactory. The burlap is spread out over the prostrate tree top, as shown in the photographs, taking special pains to protect the blossom buds from coming in direct contact with the earth covering. A light layer of earth is now thrown over the tree and the protection is complete.

The critical time in growing peaches by this method is in the spring when growing weather begins. Close watch must be kept

to see that the blossoms do not open prematurely, or that the branch buds are not forced into tender, white growth. When the blossom buds begin to open, the covering should be loosened so as to admit light and air, but it should not all be removed. More of the covering should be removed as the weather gets warmer, but the blossoms must be exposed to the sun gradually.

Air and light are, of course, necessary for proper fertilization of the flowers, but after this process is complete and the fruit is set, all danger from the weather is considered as being over. The trees are usually raised about the middle of May at Canon City.

Raising the trees is, of course, a simple task. The ground is again watered and when wet enough the trees are raised. To be sure, trees that have been treated in this manner will not usually stand upright unsupported. Consequently they are propped up at an angle, usually two props being required to keep the wind from swaying them.

When this method of growing peaches was first presented before the State Horticultural Society by Senator Felton, it was received with not a little sarcasm by some of the members, but the practicability of laying down trees is now no longer questioned. The constantly increasing acreage of peaches at Canon City proves that it pays. The actual expense is, of course, difficult to estimate, because of the attention required in the spring. The cost of the fall work can be estimated, however, as it has been found that two men will lay down and cover twenty-five of the largest trees in a day.

This process seems to be in no way detrimental to the health of the trees, since they live as long and bear as much fruit according to the size of the top as those grown in peach sections. It is, of course, necessary to cut out the wide spreading branches and thus reduce the size of the top in order to lessen the work of covering.

The following is the record of yields as given by Mr. Rickard: In 1902, 150 ten-year-old trees and 350 nine-year-old trees produced fifteen tons of fruit, or at the rate of 60 pounds per tree. In 1901 the yield was almost the same, but in 1900, 20 tons, or 80 pounds of fruit per tree was secured.

The marketing of peaches grown on this farm has thus far been a simple matter, as most of the fruit is sold at the orchard, and at prices ranging from 3 cents a pound for culls to 10 cents for fancy stock, the average price being 6 cents a pound. So long as the fruit can be sold in this way the expense of packages is reduced to a minimum.

But how about growing peaches in this manner north of the Arkansas Valley? Can it be done? Most assuredly it can, and it is done every year, but only in a small way, and the trees are so few and in such widely separated neighborhoods that they attract

**Appearance of same row on April 25 and on September 20.
Orchard of J. J. Lewis, Canon City.**

little attention. The most successful attempt of which I know has been made at Berthoud, a town 50 miles north of Denver, by M. H. Warfle. Mr. Warfle's experience is summed up in the following paragraph:

> **I have thirty peach trees. In 1901, the second year after planting, I had about twenty-five boxes of fruit. In 1902, fifty boxes, and the outlook is good for a big crop this year. The varieties I grow are Alexander, Triumph, Mountain Rose, Bakara No. 3 and Elberta. Any good variety will do well if they are laid down.**

These few pages are written not with the idea of presenting anything new, but to draw attention to the fact that peaches can be grown with a certain amount of profit in most of our fruit growing regions. But the pleasure to be derived from a home supply of this luscious fruit should not be underestimated. The peaches grown at Canon City always command a higher price on the home market because they are of better quality when allowed to ripen on the tree. Those that are shipped in must be picked before fully ripe in order to stand transportation.

In many parts of the state the price of peaches is so great that many families are compelled to do without. But by using this method of laying down the trees, as worked out by the pioneer truit growers of Canon City, the small land holder can provide his family with peaches of much better quality than can be bought on the market, and with little expense.

Bulletin 81. **March, 1903.**

The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

Onion Growing
In the Cache a la Poudre Valley.

—BY—

WENDELL PADDOCK.

PUBLISHED BY THE EXPERIMENT STATION
Fort Collins, Colorado.
1903.

Plate I. Three hundred and twenty sacks per acre.

Onion Growing in the Cache a la Poudre Valley.

By WENDELL PADDOCK.

Colorado is remarkable for its special crops which have been developed to a high degree of perfection in certain localities. And of these, few have attracted more attention than onion growing in the Cache a la Poudre valley. As early as 1880 a few gardeners in the vicinity of Laporte, began to grow more onions than were required to meet the local demand. Much of the surplus was hauled by wagon to Cheyenne, Wyoming, or it was disposed of to ranchmen, and in small towns where there was no local supply. At this time onions brought from $1.75 to $1.90 per hundred pounds. Commission men from Greeley were not slow to recognize in this crop a valuable means of supplementing the sale of potatoes. These men soon became the principal buyers. With the advent of the commission men, the acreage devoted to this crop increased rapidly, until now onions are grown in varying amounts on the bottom lands adjacent to the river from the foot hills to its junction with the Platte at Greeley, a distance of forty miles; the territory adjacent to Fort Collins still continuing to grow the largest acreage.

While the price of onions has been reduced to a minimum, 65c to 75c per hundred pounds being the average price in the fall, yet the crop is usually a paying one. Owners of small tracts of land find it profitable to put in small patches of the best soil, and perhaps the larger part of the onions is grown in this way. But occasionally a twenty-five-acre field is seen, and ten-acre fields of onions are not at all uncommon.

Soils. The onion thrives best in a cool, moist soil, the surface of which is easily kept in a mellow condition. Such soils are mostly confined to river bottoms, and they contain more vegetable matter and more sand than is commonly found in Colorado soils. Large amounts of decayed vegetable matter seem to be essential to the best development of this crop. Many of the best onion districts in the East, as well as in California, are located on reclaimed swamp land. One very important effect of the vegetable matter is that it improves the physical condition of the soil,

and if this is combined with a certain amount of sand a loam is formed that is easily made into the proverbial onion bed.

Heavier soils are not suitable for onion growing, for the following reasons: It is difficult to make a good seed bed, free from lumps. The seeds do not germinate quickly and the young plants are fragile, consequently much damage is done if the ground bakes or cracks, as it is liable to do, before the plants come up. Germination may be seriously interfered with, or the young plants killed or injured so that their development is checked. Such soils are difficult to cultivate, especially when the plants are small, and after irrigation is begun the tendency to bake is greatly augmented. The percentage of scallions, or thick-necked onions, is much greater on such soils.

The onion plant is a surface feeder, consequently it must have an abundant supply of readily available plant food in the surface soil. If the ground is compact the roots cannot nourish the plant properly, even though plant food is abundant. Then, too, the bulb must be free to expand naturally on the surface of the ground, which it can only do when the soil is loose. If the soil is compact, development is arrested and the onions are small and many scallions are formed. Many onions are grown on soils that are heavier than is desirable, but special care is taken in irrigation and cultivation.

Preparation of Land. In preparing land for onion growing, the growers are divided in their opinions and practice in regard to spring and fall plowing. Perhaps the majority plow in the spring or late winter. Fall plowing has advantages for certain soils, as it tends to kill out weeds, such as wild oats, and if the ground is inclined to be lumpy the action of frost tends to reduce the lumps and thus much time and labor is saved.

After the ground is plowed it must be harrowed and gone over with a clod crusher until it is in a fine state of tilth. Ground as ordinarily prepared for wheat will not do for onions. After the soil has been thoroughly prepared the surface must be leveled so that there will be no possibility of water standing on any portion of the field.

Fertilizing. Rotation is not usually practiced, the same land being planted to onions for several years in succession. Comparatively large amounts of manure are required to keep up the fertility of the soil under these conditions. The practice of some growers is to apply from 30 to 40 tons of sheep or horse manure per acre once in two years, while others make a similar application every three years. Of the two kinds, sheep manure is preferred. Commercial fertilizers have probably not been tried in this valley.

Plate II. Single row system of planting.

Seeding. Seeding is begun as early as March 15, and is continued as late as April 20, though it is desirable that all seed be in the ground by the 10th of April. The importance of early seeding should be emphasized, as it is essential that the bulbs make as much growth as possible before the hot weather of midsummer comes on. The seed is sown about one inch deep, with hand seed drills, using from three and one half to four pounds of seed per acre. The distance between the rows depends on the system of irrigation to be followed. If the field is to be flooded the rows are usually made 12 or 14 inches apart (Plate II). But if the furrow system of irrigation is adopted, the ground is plowed out in ridges after it has been thoroughly prepared. The ridges are made 30 inches apart and then flattened to about nine inches on top. Two rows, three inches apart, are planted on each ridge; the furrows between the double rows being used for irrigation and for cultivation (Plate III). Most growers try to plant the seed so that the plants will be one and one half inches apart in the row, so as to avoid thinning. In fact, but little thinning is done in this vicinity.

Cultivation. Cultivation and weeding is begun by hand as soon as the plants appear above ground. Cultivation is given with a hand wheel hoe, while weeding and thinning, if thinning is necessary, must be done by hand. The number of hand weedings that are necessary will depend on the season, but usually three are sufficient. The ground should be cultivated after each weeding, and at such other times as the season indicates. Four or five cultivations are required in the vicinity of Fort Collins.

It is important that weeding be attended to promptly, lest the plants become weak and spindling from the crowding of the weeds. Many plants may be killed during the process of weeding, and others may soon dry out and die as a result of being suddenly exposed to the sun.

Irrigation. Specific directions for irrigating onion fields cannot be given, since methods must necessarily differ in different fields and in different seasons. In the first place, damp, but not wet soils, are selected, when possible. Such a soil does not need much water in the fore part of the season, and when of the proper texture the fields may be flooded, when water must be applied without damaging the crop by subsequent baking of the surface. In the vicinity of Fort Collins irrigation is not begun before the first of July, and is continued at intervals of ten days or two weeks, according to the conditions of the season. Further down the river, where heavier soils are used, the ground is irrigated by running the water in furrows between double rows, as mentioned above. In this case irrigation is started the same day that the

seed is planted, if the ground is dry, or as soon after as possible. Subsequent irrigation will depend on weather conditions, but close attention must be given to see that the ground is kept moist. On the other hand, too much water must not be applied, as it results in the formation of scallions and of spongy bulbs.

Harvesting. Onion harvest is commonly begun by the 15th of September, and the crop is usually out of the field by the middle of October. Harvesting should begin promptly when the bulbs are mature, as is indicated by the withering of the tops and the yellowing of the necks.

The onions are pulled by hand and thrown into windrows, where they are allowed to remain for several days to cure. After the curing process is complete the bulbs are topped, sorted and sacked. Topping is done by cutting off the tops about half an inch above the bulb, care being taken to make a smooth, clean cut, and not to injure the outer coverings. If more top is left on it detracts from the appearance, and if cut closer the bulb is liable to be injured.

The onions are now sorted and sacked in the field, making but one grade. The small and unmarketable bulbs, together with the scallions, are left on the ground. Gunny sacks which hold about 100 pounds are the only packages used.

Ordinarily damage by rain is not feared after the onions are sacked, but if they do become wet they should be left in the field until dry. The sacks should be turned as soon as the tops are dry in order that the bottom of the sacks may have an equal chance to dry out. This is especially true if the ground is wet.

The growers do not usually attempt to hold their crop, but haul it directly to the car or to the dealer's warehouse. All onions should be out of the field by the first of November.

Markets. The principal market for Colorado onions is in Texas, though some are sent to Oklahoma and Indian Territory, and occasionally they are sent as far east as Kansas City and St. Louis. A portion of the crop is disposed of by the dealers soon after it is delivered by the growers, but perhaps two thirds of it is held until February. Onions that are held any length of time in storage must be resorted before they are placed on the market.

Varieties. A great many varieties of onions have been tested by the growers in this district, but none have been found that meets all requirements as well as the Yellow Globe Danvers. It is practically the only variety grown. A few Red Danvers are grown, but the amount is scarcely worthy of mention. The Yellow Globe seems to be well adapted to our conditions of soil, altitude and climate; it yields well, keeps well, and its size and appearance meet the demands of the market.

Plate III. Double row system of planting.

Several years ago Mr. A. T. Gilkison, of Laporte, experimented with transplanting Prizetaker onions, as is extensively practiced in other states. The onions yielded well but the bulbs did not keep well, and were larger than the market demands. Judging from this experience, the so-called new onion culture is not adapted to our conditions.

Seed. Too much attention cannot be given to procuring good seed. If the seed is old, its germinating powers may be lost or impaired, and if close attention is not given to selecting the best bulbs for seed, the stock deteriorates rapidly. Poor seed may be accountable for a poor stand, many small and immature bulbs, or a large per cent. of scallions. Onions grown from seed as commonly supplied from seedsmen, are so greatly influenced by our conditions of altitude and climate that the growers soon began to raise their own seed. The larger part of the seed now sown in in this valley is home grown.

Cost of Growing. Onion growers differ in regard to the cost of producing this crop. Of seven growers consulted, one estimated the expense at $90 an acre; another at $50. The other five gave figures varying between these extremes. It is probable that on an average $60 will cover all the expense, excepting the cost of manuring, from plowing the land to loading the onions on the cars.

Storing. It has been found that onions keep better in rooms above ground than in cellars. Such rooms should be open so as to admit of a free circulation of air until there is danger of freezing. When severe weather comes on a stove should be placed in the room if necessary to keep the bulbs from freezing. There is always more or less loss in storing onions, as many of the bulbs sprout, especially if they were not thoroughly cured; and others will decay, even though they have been only slightly bruised. In any case there will be a large shrinkage, and if the ventilation and temperature are not closely attended to, large losses may result.

Onions are sometimes kept by allowing them to freeze. If they can be kept frozen and allowed to thaw out gradually just before marketing, no harm results. But successive freezing and thawing injures the bulbs. In general this method of keeping onions cannot be commended.

Insects and Diseases. Fortunately but few insect pests or plant diseases have appeared in Colorado. Grasshoppers occasionally feed on the tops, but they do not often appear until comparatively late in the season, after alfalfa and similar crops have been harvested. They may be successfully combated by scattering poisoned bran along the sides of the field. The mixture is made

in the proportion of one pound of Paris green to twenty pounds of bran, with enough water to thoroughly moisten the mass.

A minute insect known as thrips is present every year. It sucks the juice from the leaves, causing them to have a sickly, blighted appearance. These insects do considerable damage, especially in hot, dry seasons; but as yet no method of combating them is in use.

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The Agricultural Experiment Station

OF THE

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Colorado Irrigation Waters and Their Changes.

—BY—

WILLIAM P. HEADDEN.

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Fort Collins, Colorado.
1903.

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FORT COLLINS, COLORADO.

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COLORADO IRRIGATION WATERS AND THEIR CHANGES.

BY WM. P. HEADDEN.

§ 1. The irrigation waters used in this State are largely furnished by the melting of the snows which accumulate in the higher portions of the mountains during the latter part of autumn, winter, and early spring. The springs feeding our streams are for the most part such as owe their waters to the same source, and are simply the reappearance of these waters retained by the valley soils, which are for the most part shallow and store but a small amount of water, the most of it being free to come down early in the season, before the middle of July.

§ 2. Our rivers do not descend very far into the plains before their waters are diverted from their natural courses, either to be stored or used immediately for the purposes of irrigation. The water supply is becoming a question of such importance and commands so high a price that large expenditures are being made to prevent the storm and flood waters from going to waste by running down to lower levels.

§ 3. The simple diversion of the waters from their natural courses does not change their character provided the character of the course is not changed. This, however, is not the case. These waters flow but short distances through mountainous and sparsely populated sections of country, where the water entering them from the adjacent country is of the same character as that of the stream itself. The collecting grounds are for the most part covered with a thin granitic soil bearing some forest and other mountain vegetation; but a very considerable area consists of naked schists and granites. The lower portions of these streams usually flow through fertile valleys, often under cultivation. The waters are sometimes diverted in the higher portions of their courses and at every point below this where their volume and the contour of the country will permit.

§ 4. The Cache a la Poudre river flows for the first fifty miles of its course over bowlders of schist and granite, and then over gravel and sand of the same character. The North Fork flows for a portion of its course through jura-triassic strata, into which it has cut its bed before emptying into the Poudre. The chief foreign constituents, that is other than those dissolved out of the rocks

of its drainage area, contained in this water are such as are introduced by the people living along its banks. The water of the Cache a la Poudre is an excellent water usually containing less than three grains of solids to the imperial gallon. The water furnished to the inhabitants of Fort Collins is taken from the Poudre about six miles below the point where the North Fork joins the Poudre, and is a mixture of Poudre and North Fork water plus a notable quantity of seepage. This water varies in the amount of total solids contained from 2.5 grains per imperial gallon to 13.5 grains, which is the maximum observed. The former sample was taken when the river was high and the influence of the North Fork and the seepage water together was not perceptible. The latter was taken when the Poudre was low. Their influence is shown by the notable increase in the amount of the total solids present.

§ 5. The conditions given for the Poudre hold for all the streams north of the Arkansas, and for those of the San Luis valley, so long as they are mountain streams. When their waters leave the mountains their courses are over rocks of younger geological formations, from which they receive waters of different quality, and their character is materially changed.

§ 6. I shall give analyses of waters from other streams, but that of the Poudre will be the only one treated of in detail. The considerations which have led me to confine myself to the study of the Poudre river water to so great an extent as I have done are evident: First, the water of the Poudre irrigates at the present time, as much if not more land than that of any other stream within the State; Second, it flows through our home valley, is easy of access, and we have fuller data and more intimate knowledge of it than of any other stream in the State; Third, irrigation has been practiced in this valley almost as long if not as long, as in any other portion of the State (a few sections where irrigation was practiced by the Mexicans excepted), extending over a period of forty-three years; Fourth, the oldest and at the same time an extensive system of reservoirs whose beginning dates back to 1875, has been made to supplement the summer flow of the river.

§ 7. Under these conditions the flow of the return waters has already been established, the first exaggerated effects of irrigating this land have passed away, and the rate at which the return waters are carrying the soluble salts from the soil has presumably approached, if it has not already reached the point, at which it will remain for years to come. The same may be assumed to be true in regard to the character of the salts taken into solution.

§ 8. In this section the period of drainage has begun, land having become valuable enough and water in such demand that drainage has already been instituted for the double purpose of preserving the land from being water-logged or seeped, and for render-

ing the water available for irrigating other land. From this time on water will be made to do duty repeatedly in the production of crops, even more so than at present, especially if the fall of the river and other conditions will permit it.

§ 9. For these reasons the Poudre presents the best subject, and the present is probably the most opportune time that has yet presented itself for such a study. The chemical questions relative to the composition of the return waters will become more involved within the next few years than they are now, because an increasing percentage of such water will have been used repeatedly before it makes its appearance as such in the river. Some of it will have passed into storage reservoirs and suffered whatever changes that may take place during the time of storage. One of the largest reservoirs within this valley has recently been completed, the purpose of which is to collect and render available waste and seepage or return water.

§ 10. The course of the river after it issues from the canyon is over the jura-triassic and cretaceous formations. The character of the river bed has but a slight influence upon the composition of the water compared with that of the return waters, the percentage of which increases as one goes down the stream; not simply because there is an increase in the number or size of the inflowing streams and springs, but also because of the amount of water which has been taken out in the upper parts of the river. There are six larger and several smaller ditches taking water from the Poudre between the mouth of the canyon and the town of Fort Collins. These ditches take at least four-fifths of the water flowing in the river above the first ditch. The gagings show that there is a small loss of water between the gaging station in the canyon, and a point below Bellvue, the city water works; but from this point on to the mouth of the river there is an irregular but increasing gain. The sewage from the town of Fort Collins, and also that of the College, which is an independent system, flows into the river below the town. The college system also carries a considerable volume of drainage water. The total volume of water returned to the river in this way is large, representing the sewage from a population of 5,000; but the total mineral matter added to the river water by the drainage is probably greater than that contained in the sewage, and this represents but a very small fraction of the mineral substances brought in by the return waters.

§ 11. There is much irrigated land in this district, from which the seepage and waste waters together with waste from the ditches, begin to return, as shown by the measurements of the river several miles above Fort Collins. There is a gain beginning a little way below the town of Bellvue, which increases as we go down the river, until at its mouth the total increase reached, in 1895,

164.4 second feet; and in 1901, 167 second feet. This gain, or the amount of water returning to the river, varies for different sections of the river, and also from year to year. The minimum flow of return waters which I find given was in March, 1894, when it amounted to 82.3 second feet. (Bulletin No. 33 of this Station.) The percentage of seepage water in the river at any given point will evidently vary from time to time, but taking the whole course of the Poudre from below Bellvue down to its mouth the amount varies from a small amount to 100 per cent. In order to obtain river water free from seepage, it is necessary to take it above the headgate of the ditch furthest up the stream; in fact we found it advisable to take it above the mouth of the North Fork.

§ 12. The river water as it is delivered to the town of Fort Collins, for domestic consumption, is, from a chemical standpoint, a good water for domestic purposes; but a comparison of it with the river water taken further up the stream shows that it has already suffered a considerable change, due to admixture of seepage which has found its way to the river. The object had in view in taking the samples of this water was not to examine it to determine its fitness as a potable water, but simply as a part of the larger questions relative to the changes suffered by the water when used for the purposes of irrigation.

THE CACHE A LA POUDRE RIVER WATER.

§ 13. The Cache a la Poudre, very generally called the "Poudre," and its tributaries, drain a mountainous area of about 1,050 square miles before it enters the plains section. These 1,050 square miles of drainage area present a varied surface, some of which is wooded or covered with other vegetation, much of it being naked rocks; but whether covered with a thin mountain soil, a rich valley soil or rotten rocks, there is everywhere one constant condition. The rocks are largely granite, and the soil, very naturally, is granitic too. The waters flow over granite bowlders, are retained in the interstices of granitic sands or soils, and whatever mineral matter is taken into solution by the waters is derived from the minerals making up the granite, gneiss or schist, as the case may be. The snows on the mountains by their melting yield the water which finds its way to the valleys to be later used for immediate irrigation or stored for subsequent use. I shall endeavor to follow the changes produced in the composition of this water from the time it melts, when I shall assume it to be practically pure water, until it leaves the Poudre to join the Platte. There are many difficulties in this study, and I shall be compelled to leave many questions wholly unanswered and others with very general answers.

§ 14. The most surprising change in the series suffered by this water is perhaps the very first one, that is, the change produc-

ed in the content and composition of its mineral constituents while it is still within its mountain area and before it debouches from its canyon into the plains. As snow we may consider it free from any mineral content, and as river water it is very pure, but not free from mineral matter. It has already been at work upon the rocks. It has taken from the air some carbon dioxid and gotten a little more from the decaying organic matter with which it has come in contact, and with this to aid it, it has taken up from 2.5 to four or five grains of mineral matter to each imperial gallon that flows through its canyon. Even its flood waters find time enough to dissolve out of the rock the smaller quantity, i. e., 2.5 grains per imperial gallon. It may seem to some an incredible thing that this should be so, but we can imitate it, and show that in a comparatively short time pure water in the presence of carbon dioxid can take up upwards of 4.5 grains of mineral matter per gallon from these very rocks, or rather from some of their constituents. There is no doubt about either the fact or the source from which the mineral content of the water is derived. The amount dissolved may surprise us, and we may wonder why the rocks have lasted so long, but we all know that the surface of the rocks is worn and that many of them are rotten for many feet below the surface, even crumbled so that they can be moved with pick and shovel. Some of the streets of the city of Denver are covered with such material as are our walks and drives. Those of us who have traveled on almost any of our mountain railroads have seen cuts of five, ten or more feet in depth made through such material, aggregating many miles. The geologist finds everywhere the products left by the water; sometimes they are thick beds of clay, at others simply rock debris. He sees in the soil a testimony of its persistent action whereby it has loosened the bonds which bound the little grains now constituting the particles of soil to their fellows, dissolving some, changing others, and carrying still others away. Each step that he describes is susceptible of observation or direct proof, however slowly they may seem to proceed or however great their aggregate results.

§ 15. The water of the Poudre, as already stated, is derived from the melting snows of the Laramie and Medicine Bow ranges, but by the time it has reached its canyon it has taken up a considerable amount of matter from the rocks. If we assume the flow to be 300 second-feet and the dissolved matter to be 2.25 grains per imperial gallon, the amount of mineral matter removed from its drainage area per day would be close to twenty-six tons, or taking the specific gravity at 2.6, almost 320 cubic feet of solid rock material every twenty-four hours. Even these figures represent only the amount carried at this point in the course of the stream, and not the total chemical work done by the water, for it is very probable that a series of changes have taken place, beginning with the

first action of the pure water upon the rock particles whereby a part of the substances originally dissolved has been removed, and it is only that portion which has escaped removal from solution that we find in the water in the lower mountain section of the stream. In addition to this the remaining rock has also been altered, and its new condition represents a further fraction of the work accomplished by the water.

§ 16. This is, in general terms, a statement of the process by which our waters obtain their burden, be it great or small, of mineral matter in these mountainous sections where the principal or only source from which they obtain it is the constituent minerals of the rock by direct attack upon them; and the products so formed are not modified, except by the agencies universally present, as for instance, the air or the interaction of solutions, differing only slightly from one another. This is wholly changed, as we shall see, when we come to such conditions as prevail in the soils. A fuller consideration of the changes which we are able to trace will I think help us materially, both in answering the questions arising relative to the points of attack, the course of the changes taking place in the minerals, and prepare the way for a better understanding of the manner of formation and properties of the soil. The object of this bulletin, however, is to take up the study of the river water and the changes it suffers when used for irrigation, in so far as we may be able to unravel them; and if we do not succeed in a satisfactory measure we still hope that the data accumulated may be interpreted by others to the furtherance of the object here attempted.

§ 17. In Bulletin No. 65, entitled "A Soil Study, Part III., The Soil," I stated that, in my own view, the study reduced itself to an investigation of the various decomposition products of felspar; not that other minerals might not be participants in these changes, but simply as a fact in this case, that we had an orthoclase felspar to deal with together with the products of its alteration. What these products are will undoubtedly vary under different conditions. Two conditions, however, obtain everywhere; the presence of water and of carbonic acid, and to these we appeal as the chief agents in the changes whereby, among others, the food elements contained in the rock particles of the soil are made available. It has been customary to consider certain mineral combinations which were supposed to be formed by the action of various agents upon the rock particles within the soil as intermediate agents, serving the purpose of retaining and conveniently giving up certain elements of plant food. This function has been attributed to a group of minerals called zeolites, and to express this property of the soil we find the expression zeolitic constituents. So far as the study of the action of water on felspar goes, it throws no light upon this view, and we de-

tect nothing favoring the assumption of the formation of zeolites in this manner. The general trend of the evidence is that there is a greater similarity to the conditions existing in veins than to those conditions where zeolites are formed. The theory of the existence of zeolitic constituents within the soil is convenient for many reasons, but it is doubtful whether it is correct for all soils, if it is for any.

§ 18. In Bulletin No. 65 I have shown to how great an extent our soils are made up of felspar particles, and have also held that they owe their origin to the disintegration of the granites and gneisses of the Front or Colorado range. It clearly follows that the present rivers or the streams which they now represent, have contributed in the past, as they are now doing, to this work. The contribution made by the Poudre being, according to the assumption previously made, 320 cubic feet of solid rock taken into solution daily from the area of 1,050 square miles. This result is entirely apart from its mechanical action by which a manifold greater mass is broken down and moved from one place to another. It may not be removed very far, but it is on its way to a new resting place.

§ 19. The statement that the clear water of the river which we are accustomed to think of as pure snow water, is daily carrying not less than twenty-six tons or 320 cubic feet of solid rock from the mountains down to the plains, is so large that it will undoubtedly strike the average person as over-estimated. But such is not the case, for by direct experiment we have succeeded in bringing into solution a little more than twice the amount per gallon assumed to be present in the calculation.

§ 20. Finely powdered felspar was taken and treated for fourteen and one-half days with water and carbonic acid, and we found that the solution had dissolved out of the felspar constituents equivalent to 4.53 plus grains per gallon, and this amount, 4.536 grains, would not be considered a large quantity of mineral matter to be found, even in the water of mountain streams. This would give us rather more than double as much, or 640 cubic feet per day instead of 320, as previously assumed. The aggregate removed, whether it be measured in tons or cubic feet, is a considerable quantity. The range of total solids contained in the Poudre water is from 2.6 grains to 4.6 grains; in other words, assuming a flow of 300 second-feet, the amount actually removed daily lies between 320 and 640 cubic feet of rock material weighing about 26 tons for the lower figures or 52 tons for the higher.

THE SOURCE OF THE MATERIAL.

§ 21. I have alluded to the felspar as the source from which the water obtained its mineral matter in this case. It is not in-

tended to assert that this mineral is the only one on which the water, carbonic acid, and whatever other agencies co-operate with them act, but it is the principal one; and this is true to such an extent that we may neglect all others. The prevailing rock within the drainage area is either granite, gneiss or mica schist. There are a few eruptives within this area, and locally a little hornblende-schist occurs; but these form no large areas, so we confine ourselves to the consideration of the felspar of the granite, which is an orthoclase. This statement does not exclude the occurrence of other varieties, but they are altogether subordinate. The preceding facts constituted one reason why I chose a typical orthoclase for experimentation. A second reason was the observation that our soil consists largely of grains of this mineral. The results of experiments with this mineral then give us a measure whereby to judge to what extent the Poudre water obtains its mineral matter from this source; and, secondly, a clue as to what is going on in the soil, which, however, is only of incidental interest at this time.

§ 22. A portion of felspar, orthoclase, was ground very fine, passing through a 100-mesh sieve, and treated for 22 days with water containing carbon dioxid in solution. At the expiration of this time air was caused to pass through it whereby any ferrous salts would be oxidized and the ferric hydrate precipitated. By doing this we imitate the action which we see taking place in the river waters, especially when derived from springs in whose waters iron may be held in the form of ferrous salts. We found in this case that we obtained a copious precipitate of the hydrated ferric oxid. The filtered water was evaporated in platinum dishes to avoid obtaining any silica or potash, as might have been the case had we used a porcelain or copper dish to evaporate in. The amount of total solids obtained corresponded to 1.68 grains to the imperial gallon. I will here observe that the results of all the experiments that I made indicate that the amount dissolved is proportional to the time the water is in contact with the felspar, at least for such times as my experiments continued, other conditions being the same. The residue obtained had the following composition:—

TABLE I.—ANALYSIS OF PORTION OF FELSPAR DISSOLVED BY WATER AND CARBONIC ACID IN TWENTY-TWO DAYS.

Analytical Results.	*Per Cent.*
Silicic Acid	14.353
Sulfuric Acid	9.879
Carbonic Acid	19.874
Phosphoric acid	0.381
Chlorin	3.170
Aluminic Oxid	1.119
Ferric Oxid	0.136
Calcic Oxid	23.412
Strontic Oxid	Heavy trace.
Magnesic Oxid	1.919
Potassic Oxid	11.279
Sodic Oxid	6.491
Lithic Oxid	Trace.
Ignition	25.337
Sum	117.370
Less carbonic acid and oxygen equivalent to chlorin *	20.588
Total	96.782

Combined.	*Per Cent.*
Calcic Sulfate	16.806
Calcic Carbonate	29.432
Magnesic Carbonate	4.013
Potassic Chlorid	6.668
Potassic Carbonate	10.367
Sodic Carbonate	3.736
Sodic Phosphate	1.257
Sodic Silicate	6.765
Aluminic Oxid	1.119
Ferric Oxid	0.136
Ignition	5.464
Excess Silicic Acid	11.018
Total	96.783

* Note.—This residue was first dried on a water bath and afterwards in a water oven, as I knew from analyses already made that there was in all probability a considerable excess of silicic acid present in a most favorable form to react with any alkaline carbonates present, which I wished to avoid. I fear that a reaction between the silicic acid and these carbonates took place during the long continued boiling and heating on the water bath necessary to evaporate the water to dryness, especially as the quantity of water was large (in this instance about twenty gallons), and the vessel in which the evaporation was carried on was small. It is also certain that on ignition, even at a gentle heat, the silicic acid reacts upon the carbonates, and perhaps other salts also, causing an excessive loss over that of moisture and organic matter. The ignition in this case was made very cautiously, but there is evidently an uncertainty about its correctness. I have repeatedly observed that in cases of ignition of such residues, even when there was not a sufficient excess of silicic acid to account for it, that the carbonic acid was completely expelled by a very gentle ignition. This may have indicated that the carbonic acid was in combination with lime as calcic carbonate; but the ignition was so gentle that I doubt whether it would have sufficed under ordinary conditions to have decomposed a corresponding amount of calcic carbonate. Other methods of determining this loss might have been adopted, but the amount of material at my disposal made ignition the most feasible one, it being quite certain that there was no loss of bases; and as there still remains an excess of acid, the result emphasizes this fact. I do not know in this case that the whole of the CO_2 was expelled, but I have assumed it to have been, and have accordingly taken it together with the oxygen equivalent to the chlorin found from the sum of the results obtained.

§ 23. The preceding experiment does not stand alone, and was really not our principal one in this connection, but as the statement of others would add only cumulative evidence of the correctness of the conclusion that the source of the inorganic matter contained in the Poudre water is the felspar occurring everywhere

throughout the drainage area, the others wili not be given in this place

§ 24. The first two analyses of the Poudre water that I shall give ought, perhaps, to be given in the reverse order, but as I intend to give the rest of the analyses in regular order as we go down the river, I will not deviate from it in the case of these. The only reason which would justify me in doing so would be the fact that, in the case of the second analysis I know that at least one-half of the water flowing in the river at the time the sample was taken, came down the North Fork as flood water, resulting from a heavy rain which fell in the mountains of the remoter portions of its drainage area.

§ 25. For the sake of completeness and for subsequent convenience of reference I shall give with each chemical analysis the sanitary analysis of the sample; but as the latter is of subordinate importance in our study, it will follow the chemical analysis. My object in this bulletin is not to deal with the potability of the waters used for irrigation, but to learn as much as possible about the changes that they suffer and how much they add to the fertility of the land, if any, by virtue of the elements of plant food that they contain in solution, and incidentally in suspension also. The chemical analysis gives us the amount and approximately the character of the inorganic salts held in solution, and I have adopted the ordinary sanitary analysis as the means of determining the various forms in which the nitrogen occurs, as well as its total quantity. In regard to the chlorin given in the two forms of analysis, it will be observed that the amount given by the sanitary analysis is slightly higher than that given by the chemical analysis.

TABLE II.—ANALYSIS OF CACHE A LA POUDRE WATER, SAMPLE TAKEN ABOVE THE NORTH FORK, NOV. 3, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silcic Acid	20.871	0.6053
Sulfuric Acid	6.928	0.1946
Carbonic Acid	20.790	0.6029
Chlorin	3.575	0.1037
Sodic Oxid	12.931	0.3750
Potassic Oxid	2.949	0.0855
Calcic Oxid	18.741	0.5238
Strontic Oxid	Trace	Trace
Magnesic Oxid	4.336	0.1257
Ferric and Alu. Oxids	0.388	0.0113
Manganic Oxid	0.063	0.0018
Ignition	[9.233]	0.2678
Sum	100.805	------
Oxygen Equiv. to Chlorin	.805	------
Total	100.000	2.8974

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	11.782	0.3417
Calcic Carbonate	24.781	0.7186
Magnesic Carbonate	9.063	0.2628
Sodic Chlorid	5.899	0.1711
Potassic Carbonate	4.325	0.1254
Sodic Carbonate	9.146	0.2652
Sodic Silicate	8.7[illegible]	0.2544
Ferric and Alu. Oxids	0.388	0.0113
Manganic Oxids	0.063	0.0018
Ignition	[9.233]	0.2678
Sum	83.452	------
Excess Silicic Acid	16.546	0.4798
Total	99.998	2.8999

Total solids, 2.9 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	41.4286
Chlorin	1.9804
Nitrogen as Nitrates	Trace.
Nitrogen as Nitrites	None.

	Parts Per Million
Saline Ammonia	0.0350
Albuminoidal Ammonia	0.0900
Oxygen Consumed	2.5500

TABLE III.—ANALYSIS OF CACHE A LA POUDRE WATER, SAMPLE TAKEN 150 FEET ABOVE HEADGATE OF LARIMER COUNTY DITCH, JULY 30, 1902.

Analytic Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	20.542	0.5341
Sulfuric Acid	4.951	0.1287
Carbonic Acid	21.626	0.5622
Chlorin	7.619	0.1980
Sodic Oxid	8.874	0.2307
Potassic Oxid	3.286	0.0854
Calcic Oxid	23.884	0.6209
Magnesic Oxid	5.147	0.1338
Ferric and Alu. Oxids	0.894	0.0232
Manganic Oxid	0.093	0.0024
Ignition	[4.802]	0.1248
Sum	101.718	2.6443
Oxygen Equiv. to Chlorin	1.718	0.0446
Total	100.000	2.5997

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	8.420	0.2189
Calcic Carbonate	36.431	0.9471
Magnesic Carbonate	10.758	0.2797
Sodic Chlorid	12.573	0.3276
Potassic Silicate	5.391	0.1402
Sodic Silicate	4.342	0.1129
Ferric and Alu. Oxids	0.894	0.0232
Manganic Oxid	0.093	0.0024
Ignition	4.802	0.1248
Sum	83.704	------
Excess Silicic Acid	16.296	0.4237
Total	100.000	2.6005

Total solids, 2.6 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total solids	37.1400
Chlorin	2.8300
Nitrogen as Nitrates	0.1000
Nitrogen as Nitrites	None

	Parts Per Million.
Saline Ammonia	0.0200
Albuminoidal Ammonia	0.3400
Oxygen Consumed	1.6570

TABLE IV.—ANALYSIS OF CACHE A LA POUDRE WATER, SAMPLE TAKEN FROM FAUCET IN CHEMICAL LABORATORY, MAY 23, 1897.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	36.180	1.664
Sulfuric Acid	5.180	0.238
Carbonic Acid	20.860	0.960
Chlorin	Trace	Trace
Sodic Oxid	8.000	0.368
Calcic Oxid	15.960	0.734
Magnesic Oxid	5.060	0.233
Ferric and Alu. Oxids	2.290	0.105
Manganic Oxid	Trace	Trace
Ignition	6.470	0.298
Sum	100.000	4.600
Oxygen Equiv. to Chlorin	Trace.	
Total	100.000	4.600

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	8.800	0.405
Calcic Carbonate	22.000	1.012
Magnesic Carbonate	10.580	0.487
Sodic Carbonate	13.680	0.629
Ferric and Alu. Oxids	2.290	0.105
Manganic Oxid	Trace	Trace
Ignition	6.470	0.298
Silicic Acid	36.180	1.664
Total	100.000	4.600

Total solids, 4.60 grains per imperial gallon.
Saline Ammonia, 0.00740 parts per million.
Albuminoidal Ammonia, 0.00280 parts per million.

TABLE V.—SAMPLE TAKEN FROM FAUCET IN CHEMICAL LABORATORY, SEPT. 21, 1900.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	8.050	0.596
Sulfuric Acid	15.392	1.139
Carbonic Acid	22.905	1.695
Chlorin	2.248	0.166
Sodic Oxid	8.095	0.599
Potassic Oxid	0.886	0.065
Calcic Oxid	29.067	2.151
Magnesic Oxid	7.750	0.573
Ferric and Alu. Oxids	0.317	0.023
Manganic Oxid	0.050	0.004
Ignition	5.884	0.435
Sum	100.644	7.446
Oxygen Equiv. to Chlorin	0.506	0.037
Total	100.138	7.409

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	27.174	1.937
Calcic Carbonate	32.631	2.415
Magnesic Carbonate	16.272	1.204
Potassic Chlorid	1.402	0.104
Sodic Chlorid	2.611	0.193
Sodic Carbonate	0.089	0.006
Sodic Silicate	13.116	0.971
Ferric and Alu. Oxids	0.317	0.023
Manganic Oxid	0.050	0.004
Ignition	5.884	0.435
Sum	98.546	7.292
Excess Silicic Acid	1.591	0.118
Total	100.137	7.410

Total solids, 7.4 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	198.5000
Chlorin	5.7100
Nitrogen as Nitrates	0.0400
Nitrogen as Nitrites	0.0010

	Parts Per Million.
Saline Ammonia	0.0250
Albuminoidal Ammonia	0.0571
Oxygen Consumed	1.5450

TABLE VI.--SAMPLE TAKEN FROM FAUCET IN CHEMICAL LABORATORY, SEPT. 6, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	6.123	0.6245
Sulfuric Acid	18.333	1.8699
Carbonic Acid	23.266	2.3731
Chlorin	1.035	0.1055
Sodic Oxid	6.501	0.6631
Potassic Oxid	1.883	0.1921
Calcic Oxid	29.769	3.0364
Strontic Oxid	0.219	0.0223
Magnesic Oxid	8.684	0.8857
Ferric and Alu. Oxids	0.168	0.0171
Manganic Oxid	0.110	0.0112
Ignition	[4.144]	0.4226
Sum	100.235	......
Oxygen Equiv. to Chlorin	0.235	......
Total	100.000	10.2235

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	31.179	3.1802
Calcic Carbonate	30.199	3.0802
Magnesic Carbonate	18.152	1.8515
Strontic Carbonate	0.312	0.0318
Potassic Carbonate	1.338	0.1364
Sodic Chlorid	1.708	0.1742
Potassic Silicate	1.593	0.1614
Sodic Silicate	11.035	1.1255
Ferric and Alu. Oxids	0.168	0.0171
Manganic Oxid	0.110	0.0112
Ignition	[4.144]	0.4226
Sum	99.938	.....
Total	99.938	10.1921

Total solids. 10.2 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total solids	145.7143
Chlorin	19.8040
Nitrogen as Nitrates	0.1000
Nitrogen as Nitrites	None
Saline Ammonia	0.1200
Albuminoidal Ammonia	0.0500
Oxygen required *	1.2450

* Note.—The preceding analyses are expressed in two different units: In per cent. and grains per imperial gallon, for ordinary chemical analysis, and parts per million, for the sanitary analysis. I believe that there is no inconvenience caused by this, as the average reader will think of 3.1802 grains per gallon more readily than of 45.4314 parts per million. The term gallon suggests a common measure, as does also the term grain. If any one wishes to convert the term grains per imperial gallon into parts per million to suit his convenience he has simply to multiply by one hundred and divide by seven, which is easily done.

§ 26. The first three of these analyses represent the water of the Cache a la Poudre river as it issues from its mountain section without being modified by waters coming from the surface soil or from the strata of the jura-triassic or cretaceous formations. In order to make our view more general, and to save repetition, we will here include the waters of the Boulder and the Clear Creek, the analyses of which will be given later. The general similarity of the analyses, especially of the analytical results, to those obtained by the analysis of the residue obtained by the evaporation of the water with which we had treated the felspar, leaves no doubt but that the sources of the different residues were the same, and we are justified in considering the felspar which occurs abundantly throughout the drainage areas the source from which the Poudre, the Boulder, and Clear Creek obtain their mineral constituents.

§ 27. This fact is not surprising except when we attempt to express the amounts removed in figures, for everyone conversant with the rocks of the country knows that the predominant minerals are felspar, quartz, and mica, of which the quartz is the least easily attacked by water. The experiment given shows that it is a fact that this is the source of the silica, potash, lime, etc., contained in the water.

§ 28. The presence of sulfuric acid and chlorin in these waters was not easily explainable. In the jura-triassic strata we have an abundance of gypsum from which calcic sulphate might be derived, and in fact this was the source from which I considered much of this salt to have been derived; but this could not possibly be the case where the sample was taken before it had come in contact with this formation, or could have received water which had done so. The analysis of the portion of felspar dissolved by water with the aid of carbonic acid shows a surprising amount of each of these constituents—sulfuric acid, over nine per cent., and of chlorin more than three per cent. The carbon dioxid and even the air drawn through the solution was well washed to avoid the introduction of extraneous substances. The water used was freshly distilled, leaving no residue upon evaporation, and failing to show a trace of chlorin. The felspar had been tested for sulfuric acid, and showed a few hundredths of one per cent.; but it was not tested directly for chlorin. The quantity found in its aqueous extract, however, leaves no doubt of its presence. This mineral, felspar, accordingly may furnish the sulfuric acid and chlorin found in our mountain waters, as well as the total solids in general.

§ 29. There is still stronger evidence, if there were need of it, and that is the presence of strontia and lithia in the water. In Bulletin No. 35, in a note upon the ash of alfalfa, I called attention to the fact that strontia was always present, but lithia was not detected in any single instance. Again in Bulletin No. 72 I called attention to the fact that lithia was found to be generally present in the ground waters which I had examined. I do not think that I have tested a single sample of ground water (and I have tested many within the past five years), that failed to show the presence of lithia. The same may be said of the Poudre water. I have also found it present in the waters of the St. Vrain, the Boulder, Clear Creek, and in the water of the Running Lode mine taken at a depth of 825 feet; also in the waters of the South Platte and the Arkansas. Its presence in the waters of the South Platte is not so significant, for there are several springs discharging into this river which I know carry some lithia, but the relative volume of these springs is small, and I am convinced that the lithia found indicates its more general occurrence in the waters of the Platte, and the same may be said of those of the Arkansas, for I doubt whether the small

quantity brought in by the springs could be detected with ease in the quantities of water actually used. Again, the presence of strontia is demonstrable with comparative ease in both the ground waters and the river waters. These facts were difficult to explain, and puzzled me greatly, leading me to doubt the correctness of my observations until frequent repetitions established it as a fact. The presence of these in the felspar and the power of even slightly carbonated water to take them into solution accounts fully and satisfactorily for their general presence in the river and ground waters, and enables us to trace the source from which the water obtains its original content of mineral matter. It further makes it very probable that all the waters flowing out of the area presenting the same general conditions, whether they flow eastward, as in case of our streams, or westward, as in the case of the streams of the western slope, have the same general properties until changed by new conditions.

CHANGES SUFFERED WHILE FLOWING IN BED OF STREAM.

§ 30. The analyses of the Poudre water already given show clearly that such changes take place before the waters have completed any considerable portion of their course. The sample taken above the mouth of the North Fork, Nov. 3, 1902, Table II, was taken at a time when there was no flood water and after a period of good weather. The snows of the preceding season had either disappeared, or were melting so slowly as to have little or no influence upon the flow, so that the water then flowing represented the normal water of the Poudre as nearly as we could obtain it. The samples taken from a tap in the Chemical Laboratory, especially the samples represented by analyses five and six, both taken in the month of September, one in 1900, the other in 1902, represent the same water after it had flowed for a distance of about eight miles to the water works, where it passed into the city mains.

§ 31. The principal difference that we observe is that the amount of total solids has increased from less than three grains (2.9 grains), to 7.4 grains in the first instance, and 10.2 in the second, that is, from two and one-half to three and one-third times the original amount.

§ 32. The water taken in the first sample had probably flowed sixty miles over the bed of the stream, but it had received water of its own kind, coming, as it had, through granitic sands and rocks. The last two samples had flowed only eight miles further, and only a portion of this distance was over a bed of a different character; and yet in a distance of less than eight miles the amount of mineral matter held in solution has been increased by these multiples. The greatest changes, however, have not been

in the amount, but in the character of the mineral matter, which is perhaps best exhibited by the analytical results, showing that the silicic acid in the solid residue, has been reduced in percentage, but almost exactly proportionally to the increase in the amount of total solids. The sulfuric acid has been increased nearly three times in percentage, and consequently a little less than nine times in absolute amount. The amounts of soda and potash have been doubled, but their percentages reduced, while the percentages of lime and magnesia have been greatly increased, and the absolute quantities are six and eight times greater.

§ 33. The extent of this change will be more fully appreciated when we estimate the difference in the total quantity of solid matter carried by the stream in twenty-four hours, as we have done for the river above the mouth of the North Fork. We found that the river carried about twenty-six tons of inorganic material, or, assuming a specific gravity of 2.6 for the solid substances, about 320 cubic feet. Assuming the same data to hold for the river water as it passes the Fort Collins water works ditch, we obtain from 65 to 87 tons, or from 800 to 1,067 cubic feet. Taking the higher figures, we discover an increase of 62 tons, or 747 cubic feet of inorganic matter carried in solution. These figures represent the ratio of salts perfectly, and the actual amounts under the assumed flow, which, however, is too high for an average year. But if we take 150 second-feet, which is below the average, as the flow, it would still represent an increase of 31 tons daily, or about 373 cubic feet of solid matter which enters the river in the section represented, about eight miles long.

§ 34. It is evident that if a proportionate change takes place, as the water proceeds down the river it will soon be so changed that comparisons cannot profitably be made. In the case of our streams this is so greatly complicated by return waters entering the river and by direct flows being taken out for irrigation or storage that no attempt will hereafter be made to compare the results except as to some particular features.

THE EFFECT OF STORAGE.

§ 35. This problem is not at all simple, for the reason that the water collected in reservoirs is not all river water, and in order to present all the conditions faithfully a detailed study of the supply would be necessary, which is clearly out of the question for me to make. I shall present analyses of some of our principal and older reservoirs which are, so far as I know, filled from the Poudre river and receive but relatively little seepage. The amount of seepage so far as I am informed, has never been determined. The amount of rain-water which they receive may be neglected. The concentration due to evaporation is not neg-

ligible, but the amount of salts with which we shall have to deal is so large that in subsequent statements we will take no note of this factor.

§ 36. The evaporation from an unprotected surface of water at Fort Collins is about forty inches per annum, or, considering the Poudre water to carry 2.9 grains per imperial gallon, there would be added to the remaining water 400 pounds of inorganic salts for each acre of surface exposed, and if the average depth of the reservoir were, as is the case in Terry lake, about twenty feet, the difference would be about 0.5 grain per gallon. This increase may be attributed to evaporation, but it is too high, for the water does not remain in the reservoirs the whole year, as here supposed; at least the reservoirs are not full, and the actual increase due to this cause is less than 0.5 of a grain per imperial gallon. That the aggregate amount of inorganic or mineral matter is large is evident. There is, however, but little profit in indulging in calculations of this sort, as they are modifications of the one already made in regard to the amount of dissolved matter daily brought down from the mountains by the Poudre river.

§ 37. The reservoir known as Terry lake has, when full, a surface area of 470 acres, from which forty inches of water evaporate annually, leaving nearly 400 pounds on each acre, or an aggregate of 94 tons of mineral matter for the entire reservoir, which has been dissolved out of the granite of the mountains where the snows have melted. But when this quantity is compared with the figures which we shall have to use to represent the aggregate of salts carried by these reservoir waters, it will be realized that this increase in the mineral matter in such waters due to evaporation can be neglected.

§ 38. I shall give the reservoir waters in order, going down the valley, beginning with the Larimer & Weld, or Terry lake. This may not be the best order, or rather it might be well to omit Terry lake altogether, because it is not typical of the changes which I most desire to set forth, but presents them in so extreme a form as to overshadow the less extreme but probably more representative results shown by the others. This reservoir, however, is one of the oldest and stores 9,000 acre-feet of water, and although the changes presented by the water of this reservoir may be greater than in the other cases, it may alone serve to give a more adequate idea of the real extent and importance of the solvent action of water upon the soils and of the supply of the soluble salts contained and formed therein than the others.

LARIMER & WELD RESERVOIR (TERRY LAKE).

§ 39. This reservoir is situated about two miles north of Fort Collins and is filled principally by water taken from the

Poudre river, the other sources being seepage and storm water from Dry Creek, and seepage and drainage from the adjacent country. Some years these latter furnish a considerable part of the 9,000 acre-feet contained in this reservoir. While this statement is true as to the amount of water furnished, it seems very probable that these sources always furnish an unusually large amount of soluble salts. The Little Cache la Poudre ditch, which carries water from the Poudre river to the reservoir, is a comparatively short ditch and can scarcely collect more than a small part of the salts which we shall presently find contained in the water of the reservoir. The two analyses given below are of samples taken from near the center of the lake and several feet below the surface, just before the water was drawn out, the reservoir being full. The water was slightly yellow and had a slight odor.

TABLE VII—ANALYSIS OF WATER FROM THE LARIMER & WELD RESERVOIR (TERRY LAKE). SAMPLE TAKEN JULY 28, 1900.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.125	0.168
Sulfuric Acid	48.089	64.680
Carbonic Acid	4 727	6.358
Chlorin	0.982	1.321
Sodic Oxid	14.935	20.087
Potassic Oxid	0.129	0.174
Calcic Oxid	8.117	10.917
Magnesic Oxid	13.244	17 813
Ferric and Alu. Oxids	0 020	0.027
Manganic Oxid	0.040	0.054
Ignition	9.938	13.367
Sum	100.346	134.966
Oxygen equiv. to Chlorin	0.221	0.297
Total	100.125	134.669

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	19.704	26.502
Magnesic Sulfate	39.741	53.452
Potassic Sulfate	0.237	0.319
Sodic Sulfate	17.574	23.637
Sodic Chlorid	1.620	2.179
Sodic Hydric Carbonate	0.463	0.623
Sodic Carbonate	10.590	14.243
Ferric and Alu. Oxids	0.020	0.027
Manganic Oxid	0.040	0.054
Ignition	9 938	13.367
Sum	99.927	134.353
Excess Silicic Acid	0.125	0.168
Total	100.052	134.521

Total solids, 134.5 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	1,921.4000
Chlorin	24.3000
Nitrogen as Nitrates	0.2000
Nitrogen as Nitrites	2.4000

	Parts Per Million.
Saline Ammonia	0.0944
Albuminoidal Ammonia	0.6171
Oxygen required	5.9000

TABLE VIII.—ANALYSIS OF WATER TAKEN FROM THE LARIMER & WELD RESERVOIR (TERRY LAKE), JULY 30, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.117	0.205
Sulfuric Acid	53.967	94.766
Carbonic Acid	1.936	3.400
Chlorin	0.872	1.530
Sodic Oxid	15.071	26.465
Potassic Oxid	0.359	0.630
Calcic Oxid	8.893	15.616
Strontic Oxid	0.196	0.344
Magnesic Oxid	13.104	23.011
Ferric and Alu. Oxids	0.063	0.111
Manganic Oxid	Trace	Trace
Ignition	5.441	9.554
Sum	99.822	175.632
Total	99.822	175.632

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	21.606	37.940
Strontic Sulfate	0.346	0.608
Magnesic Sulfate	39.136	68.723
Potassic Sulfate	0.663	1.164
Sodic Sulfate	26.224	46.049
Sodic Chlorid	1.439	2.527
Sodic Carbonate	4.667	8.195
Sodic Silicate	0.237	0.416
Ferric and Alu. Oxids	0.063	0.111
Manganic Oxid	Trace	Trace
Ignition	5.441	9.554
Total	99.822	175.287

Total solids, 175.6 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	2,508.570
Chlorin	28.290
Nitrogen as Nitrates	0.100
Nitrogen as Nitrites	0.010

	Parts Per Million.
Saline Ammonia	0.100
Albuminoidal Ammonia	0.600
Oxygen required	2.283

§ 40. Taking the average of the total solids obtained for these two years, 1900 and 1902, determined in each case when the lake was full, we have 155.02 grains per gallon. The present capacity of the lake being 9,000 acre-feet, these figures give us 27,127 tons as the amoumt of mineral matter, only 507.5 tons of of which was originally contained in the water, assuming it all to have been taken from the river. This large amount of salts, 27,127 tons, is annually distributed over the land irrigated by this water, or about three tons per acre-foot. At the present time we are less concerned with its distribution, which we will discuss later, than with the question of its source. It matters not whether it is storm water or river water; neither of these contains the fiftieth part of the salts here represented. If it were all river water containing 2.9 grains per gallon, it would account for only about 507 tons, leaving 26,620 tons to be derived from the seepage of a comparatively small area of country. If the whole of the Dry creek seepage were turned into the reservoir, its volume would not seem to be large enough to account for this result. The distance from Terry lake to the North Poudre canal is less than nine miles, and the average width of country which seeps or drains into it is not more than three and one-half miles, at the most thirty-two square

miles. The North Poudre canal was opened about 1884, and all the seepage and waste water arising from irrigation in this area has been washing out this tract for the past eighteen or nineteen years; and as Terry lake is emptied annually, and the water collected from the Dry creek will not average more than one-third of its contents when full, it is difficult to understand how it can furnish so very large an amount of alkali salts at the present time. To present this more clearly, we will give the actual quantities of the three salts constituting the principal part of our alkalies, which are calcic, magnesic and sodic sulfates. Terry lake contained, as the average for the two years, 1900 and 1902, 23,589.63 tons of these salts, represented as follows: calcic sulfate, 5,859.43 tons; magnesic sulfate, 10,616.42 tons; and sodic sulfate, 7,113.78 tons; all calculated as anhydrous salts. The greatest amount that a like quantity of Poudre river water would have contained would have been 59.73 tons of calcic sulfate, and no magnesic or sodic sulfate; but we have estimated that two-thirds of the water filling the lake is taken directly from the river, and the amount of this salt would be 39.82 tons, leaving 5,819.61 tons to come from the Dry creek drainage area, together with all the magnesic and sodic sulfates.

§ 41. I have spoken of the drainage area as though it extended no further northward than the North Poudre canal; this is not strictly correct, but the land under the North Poudre canal is the most northerly irrigated land. I do not know what proportion of the Dry creek water is originally Poudre river water, coming from either the Poudre or the North Fork.

LONG POND.

§ 42. Long pond lies east of Terry lake and within a mile. This reservoir is filled from the Larimer county ditch, and receives much less seepage than Terry lake. It contains about one-half as much water, or about 4,500 acre feet, but presents a proportionately smaller surface. The question, however, of concentration by evaporation, even in Terry lake, is one of a half-grain or less per gallon, and will be neglected. The changes in the water in this lake are much more nearly representative of those usually taking place than is the case with Terry lake.

TABLE IX—ANALYSIS OF SAMPLE OF WATER TAKEN FROM LONG POND AUGUST 1, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.459	0.382
Sulfuric Acid	44.013	11.531
Carbonic Acid	6.653	1.743
Chlorin	1.494	0.391
Sodic Oxid	12.816	3.358
Potassic Oxid	0.799	0.209
Calcic Oxid	16.217	4.249
Magnesic Oxid	10.104	2.647
Ferric and Alu. Oxids	0.225	0.059
Manganic Oxid	Trace	Trace
Ignition	6.934	1.817
Sum	100.714	26.386
Oxygen equiv. to Chlorin	0.336	0.088
Total	100.378	26.298

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	39.401	10.323
Magnesic Sulfate	30.177	7.906
Potassic Sulfate	1.476	0.387
Sodic Sulfate	0.128	0.034
Sodic Chlorid	2.465	0.646
Sodic Carbonate	16.042	4.203
Sodic Silicate	2.959	0.775
Ferric and Alu. Oxids	0.225	0.059
Manganic Oxid	Trace	Trace
Ignition	6.934	1.817
Sum	99.807	26.150
Excess Sodic Oxid	0.570	0.149
Total	100.377	26.299

Total solids, 26.2 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	374.290
Chlorin	7.070
Nitrogen as Nitrates	Trace
Nitrogen as Nitrites	None

	Parts Per Million.
Saline Ammonia	0.050
Albuminoidal Ammonia	0.280
Oxygen consumed	3.296

WARREN'S LAKE.

§ 43. Warren's lake lies six miles due south of Long pond, and is filled from Larimer County No. 2 ditch, receiving a small amount of seepage and waste water. The distance from the headgate of the ditch to the reservoir is about eight miles. The sample was taken near the gate. Depth of water, ten feet.

TABLE X.—ANALYSIS OF SAMPLE OF WATER TAKEN FROM WARREN'S LAKE, AUGUST 4, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	2.210	0.407
Sulfuric Acid	30.826	5.672
Carbonic Acid	14.284	2.628
Chlorin	3.323	0.611
Sodic Oxid	12.327	2.268
Potassic Oxid	1.361	0.250
Calcic Oxid	19.672	3.620
Magnesic Oxid	9.800	1.803
Ferric and Alu. Oxids	0.400	0.074
Manganic Oxid	0.092	0.017
Ignition	6.434	1.184
Sum	100.749	18.534
Oxygen Equiv. to Chlorin	0.749	0.138
Total	100.000	18.396

Combined	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	47.796	8.794
Magnesic Sulfate	4.064	0.748
Magnesic Carbonate	17.636	3.245
Potassic Chlorid	2.040	0.375
Sodic Chlorid	3.883	0.714
Sodic Carbonate	12.264	2.257
Sodic Silicate	4.482	0.825
Ferric and Alu. Oxids	0.400	0.074
Manganic Oxid	0.092	0.017
Ignition	6.434	1.184
Sum	99.191	18.233
Excess Sodic Oxid	.818	0.151
Total	100.009	18.384

Total solids, 18.4 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total solids	262.860
Chlorin	9.900
Nitrogen as nitrates	0.100
Nitrogen as nitrites	0.001

	Parts Per Million.
Saline ammonia	0.180
Albuminoidal ammonia	0.420
Oxygen consumed	4.114

WINDSOR RESERVOIR.

§ 44. The capacity of this reservoir is 14,000 acre-feet and it is filled by the Larimer & Weld canal with water taken from the Poudre below the town of Laporte. The reservoir lies twelve miles east and five miles south of the headgate of the ditch. The actual length of the ditch through which the water flows is probably not far from 13.5 miles. The lake was full at the time the sample was taken. Its owners began to draw out the water while the sample was being taken. I do not know how much seepage and drainage water gathers in this reservoir. The higher amount of total solids present indicates a considerable accession of such waters. Terry lake discharges its water through the same canal that fills the Windsor reservoir, but as I understand the matter, these two reservoirs belong to different companies, and as both reservoirs were full at the time the samples were taken, it is not probable that any of the salts held in the water of Windsor lake came from Terry lake water, but represent the influence of the area from which the lake receives seepage. This, of course, includes the lake bed itself.

TABLE XI.—ANALYSIS OF SAMPLE OF WATER TAKEN FROM WINDSOR RESERVOIR, AUGUST 5, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.380	0.264
Sulfuric Acid	50.149	34.803
Carbonic Acid	3.854	2.675
Chlorin	1.890	1.312
Sodic Oxid	12.109	8.404
Potassic Oxid	0.541	0.375
Calcic Oxid	13.254	9.198
Magnesic Oxid	12.475	8.658
Ferric and Alu. Oxids	0.289	0.201
Manganic Oxid	0.070	0.049
Ignition	[5.415]	3.758
Sum	100.426	69.697
Oxygen Equiv. to Chlorin	0.426	0.296
Total	100.000	69.401

Combined	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	32.202	22.348
Magnesic Sulfate	37.258	25.857
Potassic Sulfate	1.000	0.694
Sodic Sulfate	10.581	7.343
Sodic Chlorid	3.119	2.165
Sodic Carbonate	9.294	6.446
Sodic Silicate	0.770	0.534
Ferric and Alu. Oxids	0.289	0.201
Manganic Oxid	0.070	0.049
Ignition	[5.415]	3.758
Sum	100.000	69.395
Excess	None	None
Total	100.000	69.395

Total solids, 69.4 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	991.430
Chlorin	27.730
Nitrogen as Nitrates	0.100
Nitrogen as Nitrites	0.001

	Parts Per Million.
Saline ammonia	0.040
Albuminoidal ammonia	0.360
Oxygen consumed	3.634

§ 45. We have in this case, as in that of Terry lake, and in the others to a less degree, a very noticeable increase in the amount of total solids. Taking the capacity of this lake as 14,000 acre-feet (14,004 is the correct capacity) we find that there are 18,894.15 tons of salts held in solution, while a like quantity of Poudre water would contain only 789.5 tons, showing 18,104.6 tons collected by the lake during the period intervening between the two drawings-off—a period of approximately a year. The capacity of Terry lake is 9,000, that of Windsor lake 14,000 acre-feet. Terry lake collected 27,127 tons, and Windsor lake 18,894 tons, of mineral matter in a year. The amount of these salts is very different, the smaller lake or reservoir having collected one-half more than the larger one.

§ 46. The relative quantities of the various salts are also quite different in these cases. For instance, Terry lake collected 5,859.4 tons of calcic sulfate, anhydrous; Windsor lake, 6,083.29 tons. Terry lake collected 10,616.4 tons of magnesic sulfate; Windsor lake 7,029.58 tons. Of sodic sulfate, Terry lake collected 7,113.78 tons; Windsor lake, 1,999.19 tons. Of sodic carbonate Terry lake collected, average of two years, 2,069.25 tons; Windsor

lake, 1,756.02 tons. To the average person, these figures convey but an inadequate idea of the amount of salts dissolved by these lake waters. If we put it, as is sometimes done, in terms of the transportation facilities which would be necessary to move this combined amount, it may give a clearer notion of the quantity of salts moved by these two lakes. The amount of salts carried out by the annual emptying of these lakes is 46,021 tons, which would require 1,534 cars each holding thirty tons, which, allowing 35 feet as the length of a car, would represent a train ten miles long, not including engines.

THE FERTILIZING VALUE OF THESE SALTS.

§ 47. As the water whose composition we have so far presented is used for irrigating purposes, it may not be amiss to discuss the fertilizing value as it is indicated by the various analyses. The only constituent in the ordinary chemical analysis which is of importance in this respect is the potassic oxid. Our soils contain lime enough to meet the requirements of all cultivated crops. The advisability of adding lime because of its chemical action on the soil is left entirely out of the question, and if it were considered, the form in which the lime is present in the waters would render it of little value, except in a very limited range of cases. We will then simply endeavor to find how much potash these waters would add to the soil if the whole of it were retained and were available to plants as food. These assumptions are made for convenience of presentation only, and for the same reason we will make no distinction between the waters of the different reservoirs, but will take them in the aggregate.

§ 48. The capacity of the four reservoirs is 27,672 acre-feet. Allowing two feet per acre, they would together irrigate 13,836 acres of land. The aggregate amount of potassic oxid found in them was 188.06 tons, equivalent to 347.9 tons of sulfate of potash, which would give almost exactly 50 pounds of sulfate of potash per acre irrigated, equivalent to a dressing of 200 pounds of the average kainit of commerce. It will be recalled that the percentage of potash found in the waters was not uniform, that from Warren's lake yielding the highest. It will also be recalled that the Poudre water as taken from the river to fill these lakes furnishes an insignificant part of this potash; therefore, it is evident that the main supply must have come from seepage. Long pond and Warren's lake receive less seepage than the other two, and when we calculate the amount of sulfate of potash which their waters add to the soil irrigated with it, as we have for the four taken together, we find that an acre receives the equivalent of only 31 pounds, instead of 50 pounds; and if we should use water directly from the river, as it comes through the canyon, it would add the

equivalent of only 12.5 pounds. This last quantity is high in proportion to the amount of mineral matter added, owing to the higher percentage of potash present in the total solids.

§ 49. The sanitary analyses show that the changes suffered while the water is stored do not, in their total results, materially affect the quality of the water, the albuminoidal ammonia, and in one instance the nitrites, alone showing material changes. They also show that the amount of nitrogen added in all forms is utterly insignificant—less than four pounds per acre in the most favorable instance.

§ 50. We see that the amount of plant food distributed by means of the irrigation water, whether it be stored water or such as is used directly from the river, is not so great as might have been expected, but its effect, if the potash present is really available for the use of plants, would undoubtedly aid materially in maintaining the fertility of the soil. In the case of the stored water the potash applied in the course of four years would amount to a dressing of 800 pounds of kainit.

§ 51. There is another question, i. e., how much do we add of other salts which are useless and may be deleterious? To this suggestion the answer is that, taking the aggregate results of the four reservoirs, as we did in the case of the potash when we found that the equivalent of 50 pounds of sulfate of potash per acre was added yearly, we find that with this amount of potash there is added 3.49 tons, 6,980 pounds, of other salts. This result seems large, but if we calculate the amount of salts added per acre when two feet of Windsor or Terry lake water is applied, we shall find still larger quantities. Windsor lake is the largest of the four and is intermediate as to the amount of salts held in solution between Terry lake and the others, and we will for this reason analyze the results obtained from the examination of its water. The capacity of the lake is 14,000 acre-feet, and its water holds in solution 18,894.15 tons of total solids. An application of two feet of water per acre will distribute this over 7,000 acres, or 2.7 tons or 5,400 pounds per acre. The potash contained in this is equivalent to 53.6 pounds of sulfate of potash per acre. The calcic sulfate amounts to 1,738 pounds; magnesic sulfate, 2,000 pounds; sodic sulfate, 542 pounds; sodic carbonate, 250 pounds; sodic chlorid, salt, 174 pounds; other substances, 330 pounds.

§ 52. A like application of Terry lake water would add to each acre: potash equivalent to 54.5 pounds of sulfate of potash; 2,604 pounds calcic sulfate; 4,718 pounds of magnesic sulfate; 3,162 pounds of sodic sulphate and 919 pounds of sodic carbonate.

§ 53. The above figures are for anhydrous salts, but they are doubtlessly present in the hydrated condition, and if calculated as such would be represented by large numbers.

THE CHANGES EFFECTED IN THE WATER USED IN IRRIGATION.

§ 54. It seems proper to take up this subject before we present that of the return waters. The changes produced will depend upon the character of the soil irrigated and will probably differ in the case of sod-covered land and in that of land under cultivation.

§ 55. The facts recorded in the preceding paragraphs relative to the changes, which took place during storage for the comparatively short period of one season, clearly indicate that the only proper basis from which to start would be Poudre water taken for direct irrigation and a perfectly typical soil. These conditions might have been met but it would have been with difficulty.

§ 56. The first series of samples taken for the purpose of studying the changes in the composition of the water used in irrigation was taken in 1898, the second in 1899, and the third in 1900, when I availed myself of the opportunity offered by an exceptionally heavy and protracted rainfall whereby the water plane, as indicated by the hight of the water in the wells dug in different parts of the plot, was raised to within from 1.0 foot to 0.3 of a foot of the surface. The water in this case being rain water, or water produced by snow melting on the ground, eliminated the question of its composition.

§ 57. The water which I used in the following experiments in 1899 was Poudre water mixed with some seepage, but the plot of ground was not typically good soil but rather an alkali soil. Originally this soil was in a bad condition, but it had been improved by cultivation at the time this experiment was made and a part of it was then in excellent condition. The results therefore may represent those of actual practice more nearly than if the whole plot had been in the very best condition, but it clearly involves the question of alkali. It is a difficult matter to find any land where the drainage is not perfect which is entirely free from this question, especially when considered from a chemical standpoint. The instances of Terry and Windsor lakes accumulating in a single season 27,127 and 18,894 tons of salts respectively, after having been in use as storage reservoirs for at least 12 years, is suggestive of a goodly supply, particularly when we consider the comparatively small area from which these quantities of salts were collected.

§ 58. In 1898 the only water at my disposal was seepage water and the supply of this was limited. The water plane was moderately low and was raised from one to two feet in different parts of the plot. The water in the wells obtained its maximum hight in from one to five days and then fell, at first rapidly, afterwards gradually, until it reached the lowest point for the season—the maximum fall being 4.3 feet. The changes in the water will be evident from the following analyses:

TABLE XII—ANALYSIS OF WATER AS IT FLOWED ONTO PLOT JULY 8 AND 9, 1898.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.885	0.942	Calcic Sulphate	51.366	25.683
Sulfuric Acid	40.389	20.195	Magnesic Sulfate	15.272	7.636
Carbonic Acid	9.245	4.622	Magnesic Chlorid	4.296	2.148
Chlorin	3.479	1.740	Potassic Chlorid	0.567	0.284
Sodic Oxid	13.149	6.575	Potassic Carbonate	0.735	0.367
Potassic Oxid	0.859	0.429	Sodic Carbonate	21.728	10.864
Calcic Oxid	21.160	10.580	Sodic Silicate	0.851	0.426
Magnesic Oxid	6.900	3.450	Ferric and Alu. Oxids	0.077	0.039
Ferric and Alu. Oxids	0.077	0.039	Manganic Oxid	0.058	0.029
Manganic Oxid	0.058	0.029	Ignition	3.261	1.631
Ignition	3.256	1.628			
Sum	100.462	50.229	Sum	98.211	49.107
Oxygen Equiv. to Chlorin	1.784	0.392	Excess Silicic Acid	1.466	0.733
Total	99.678	49.837	Total	99.677	49.840

Total solids 50.0 grains per imperial gallon.

TABLE XIII.—ANALYSIS OF WATER AS IT FLOWED OFF AT MIDDLE OF NORTH SIDE OF THE PLOT JULY 14, 1898.*

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.079	0.791	Calcic Sulfate	29.729	21.791
Sulfuric Acid	46.877	34.361	Magnesic Sulfate	22.064	16.173
Carbonic Acid	2.895	2.122	Potassic Sulfate	2.534	1.857
Chlorin	4.288	3.143	Sodic Sulfate	24.018	17.605
Sodic Oxid	19.419	14.234	Sodic Chlorid	7.076	5.187
Potassic Oxid	1.376	1.009	Sodic Carbonate	6.981	5.117
Calcic Oxid	12.247	8.977	Sodic Silicate	2.138	1.567
Magnesic Oxid	7.353	5.390	Ferric and Alu. Oxids	0.047	0.034
Ferric and Alu. Oxids	0.047	0.034	Manganic Oxid	0.107	0.078
Manganic Oxid	0.107	0.078	Ignition	5.135	3.764
Ignition	5.135	3.764			
Sum	100.823	73.903	Sum	99.829	73.173
Oxygen Equiv. to Chlorin	0.966	0.708	Excess Silicic Acid	0.026	0.019
Total	99.857	73.195	Total	99.855	73.192

Total solids 73.3 grains per imperial gallon.

* It was an accident that enabled us to obtain this sample of run-off water. The water at our disposal for irrigating was not sufficient to produce any off-flow, but we, by an oversight, left our dam in the ditch and our distributing gates open. On the night of the 13th there was a heavy shower in the foot hills and others also having left their ditches open we obtained water enough to produce a slight off-flow. It is plain that the water which came down thus unexpectedly was storm water and was mixed with the water which we had previously been using for irrigation. The actual result was larger than is presented by the analysis. The volume of this off-flow was small and continued for a short time only.

TABLE XIV.—ANALYSIS OF WATER OF WELL C, JUNE 27, 1898. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.764	0.993
Sulfuric Acid	44.501	57.851
Carbonic Acid	3.815	4.960
Chlorin	5.521	7.177
Sodic Oxid	21.681	28.186
Potassic Oxid	0.133	0.173
Calcic Oxid	12.489	16.236
Magnesic Oxid	6.677	8.680
Ferric and Alu. Oxid	0.050	0.065
Manganic Oxid	0.031	0.040
Ignition	5.531	7.190
Sum	101.193	131.551
Oxygen Equiv. to Chlorin	1.244	1.618
Total	99.947	129.933

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	30.309	39.401
Magnesic Sulfate	20.048	26.062
Potassic Sulfate	0.246	0.320
Sodic Sulfate	23.439	30.471
Sodic Chlorid	9.108	11.840
Sodic Carbonate	9.191	11.949
Sodic Silicate	1.553	2.019
Ferric and Alu. Oxids	0.050	0.065
Manganic Oxid	0.031	0.040
Ignition	5.531	7.190
Sum	99.506	129.357
Excess Sodic Oxid	0.440	0.572
Total	99.946	129.929

Total solids 130.0 grains per imperial gallon.

* Before irrigation.

TABLE XV.—ANALYSIS OF WATER OF WELL C, JULY 11, 1898. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.398	1.620
Sulfuric Acid	48.138	195.823
Carbonic Acid	1.500	6.102
Chlorin	5.504	22.391
Sodic Oxid	17.201	69.975
Potassic Oxid	0.126	0.513
Calcic Oxid	12.046	49.002
Magnesic Oxid	9.290	37.793
Ferric and Alu. Oxids	0.276	1.122
Manganic Oxid	0.070	0.285
Ignition	6.529	26.561
Sum	101.078	411.187
Oxygen Equiv. to Chlorin	1.241	5.046
Total	99.837	406.141

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	29.233	118.918
Magnesic Sulfate	27.894	113.473
Potassic Sulfate	0.233	0.938
Sodic Sulfate	21.738	88.430
Sodic Chlorid	9 080	36.938
Sodic Carbonate	3.613	14.699
Sodic Silicate	0.809	3.290
Ferric and Alu. Oxids	0.276	1.122
Manganic Oxid	0.070	0.285
Ignition	6.529	26.561
Sum	99.475	404.654
Excess Sodic Oxid	0.359	1.460
Total	99.834	406.114

Total solids 406.8 grains per imperial gallon.

* After irrigation.

TABLE XVI.—ANALYSIS OF WATER OF WELL G, JUNE 27, 1898. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.498	1.175
Sulfuric Acid	44.062	103.986
Carbonic Acid	3.521	8.309
Chlorin	7.535	17.783
Sodic Oxid	15.055	35.530
Potassic Oxid	0.418	0.986
Calcic Oxid	16.601	39.178
Magnesic Oxid	8.015	18.915
Ferric and Alu. Oxids	0.040	0.094
Manganic Oxid	0.060	0.141
Ignition	5.940	14.018
Sum	101.745	240.115
Oxygen Equiv. to Chlorin	1.698	4.007
Total	100.047	236.108

Combined.	*Per Cent*	*Grs. Imp. Gal.*
Calcic Sulfate	40.299	95.106
Magnesic Sulfate	24 050	56.758
Potassic Sulfate	0.770	1.817
Sodic Sulfate	7.062	16.666
Sodic Chlorid	12.434	29.343
Sodic Carbonate	8.490	20.036
Sodic Silicate	0.790	1.864
Ferric and Alu. Oxids	0.040	0.094
Manganic Oxid	0.060	0.141
Ignition	9.540	14.018
Sum	99.935	235.843
Excess Silicic Acid	0.109	0.257
Total	100.044	236.100

Total solids 236.0 grains per imperial gallon.

* Before irrigation.

TABLE XVII.—ANALYSIS OF WATER OF WELL G. JULY 11, 1898. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.337	1.149
Sulfuric Acid	46.106	157.221
Carbonic Acid	3.456	11.785
Chlorin	6.317	21.541
Sodic Oxid	17.165	58.533
Potassic Oxid	1.002	3.417
Calcic Oxid	13.539	46. 68
Magnesic Oxid	9.052	30.867
Ferric and Alu. Oxids	0.070	0.239
Manganic Oxid	0.060	0.205
Ignition	4.352	14.840
Sum	101.456	345.965
Oxygen Equiv. to Chlorin	1.423	4.852
Total	100.033	341.113

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	32.866	112.073
Magnesic Sulfate	27.162	92.622
Potassic Sulfate	1.845	6 283
Sodic Sulfate	13.897	47.389
Sodic Chlorid	10.424	35.546
Sodic Carbonate	8 333	28.416
Sodic Silicate	0.684	2.332
Ferric and Alu. Oxids	0.070	0.239
Manganic Oxid	0.060	0.205
Ignition	4.352	14.840
Sum	99.693	339.945
Excess Sodic Oxid	0.337	1.149
Total	100.030	341.094

Total solids 341.0 grains per imperial gallon.

* After irrigation.

TABLE XVIII.—ANALYSIS OF WATER OF WELL B, JUNE 27, 1898. *

Analytical Results.	Per Cent.	Grs. Imp. Gal.
Silicic Acid	0.638	1.347
Sulfuric Acid	46.128	97.422
Carbonic Acid	3.187	6.731
Chlorin	6.745	14.245
Sodic Oxid	16.311	34.449
Potassic Oxid	0.378	0.798
Calcic Oxid	15.898	33.576
Magnesic Oxid	8.021	16.940
Ferric and Alu. Oxids	0.070	0.148
Manganic Oxid	0.060	0.127
Ignition	4.524	9.555
Sum	101.960	215.338
Oxygen Equiv. to Chlorin	1.520	3.210
Total	100.440	212.128

Combined.	Per Cent.	Grs. Imp. Gal.
Calcic Sulfate	38.592	81.506
Magnesic Sulfate	24.068	50.832
Potassic Sulfate	0.696	1.470
Sodic Sulfate	12.552	26.510
Sodic Chlorid	11.130	23.506
Sodic Carbonate	7.685	16.231
Sodic Silicate	0.833	1.759
Ferric and Alu. Oxids	0.070	0.148
Manganic Oxid	0.060	0.127
Ignition	4.524	9.555
Sum	100.210	211.644
Excess Silicic Acid	0.228	0.482
Total	100.438	212.126

Total solids 211.3 grains per imperial gallon.

* Before irrigation.

TABLE XIX.—ANALYSIS OF WATER OF WELL B, JULY 11, 1898.*

Analytical Results	Per Cent.	Grs. Imp. Gal.
Silicic Acid	0.453	1.422
Sulfuric Acid	47.321	148.493
Carbonic Acid	2.086	6.546
Chlorin	4.756	14.924
Sodic Oxid	23.015	72.221
Potassic Oxid	0.188	0.590
Calcic Oxid	10.933	34.308
Magnesic Oxid	5.874	18.433
Ferric and Alu. Oxids	0.039	0.122
Manganic Oxid	0.039	0.122
Ignition	5.908	18.539
Sum	100.612	315.720
Oxygen Equiv. to Chlorin	1.072	3.364
Total	99.540	312.356

Combined.	Per Cent.	Grs. Imp. Gal.
Calcic Sulfate	26.540	83.283
Magnesic Sulfate	17.626	55.310
Potassic Sulfate	0.346	1.086
Sodic Sulfate	35.166	110.351
Sodic Chlorid	7.849	24.630
Sodic Carbonate	5.030	15.785
Sodic Silicate	0.920	2.887
Ferric and Alu. Oxids	0.039	0.122
Manganic Oxid	0.039	0.122
Ignition	5.908	18.539
Sum	99.463	312.114
Excess Sodic Oxid	0.076	0.239
Total	99.539	312.353

Total solids, 313.8 grains per imperial gallon.

* After irrigation.

TABLE XX.—ANALYSIS OF WELL A, JUNE 27, 1898.*

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.649	1.399	Calcic Sulfate	35.648	76.857
Sulfuric Acid	46.854	100.017	Magnesic Sulfate	28.750	61.985
Carbonic Acid	3.099	6.681	Potassic Sulfate	0.670	1.444
Chlorin	6.115	13.183	Sodic Sulfate	11.393	24.563
Sodic Oxid	15.289	32.963	Sodic Chlorid	10.091	21.756
Potassic Oxid	0.364	0.785	Sodic Carbonate	7.472	16.110
Calcic Oxid	14.685	31.661	Sodic Silicate	1.149	2.477
Magnesic Oxid	9.581	20.657	Ferric and Al. Oxids	0.040	0.086
Ferric and Al. Oxids	0.040	0.086	Manganic Oxid	0.060	0.129
Manganic Oxid	0.060	0.129	Ignition	4.754	10.249
Ignition	4.754	10.249			
Sum	101.490	218.810	Sum	100.027	215.656
Oxygen Equiv. to Chlorin	1.378	2.971	Excess Silicic Acid	0.083	0.179
Total	100.112	215.839	Total	100.110	215.835

Total solids, 215.6 grains per imperial gallon.
* Before irrigation.

TABLE XXI.—ANALYSIS OF WATER OF WELL A, JULY 11, 1898.*

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.265	1.092	Calcic Sulfate	26.267	108.168
Sulfuric Acid	46.461	191.326	Magnesic Sulfate	31.016	127.723
Carbonic Acid	1.984	8.172	Potassic Sulfate	0.162	0.668
Chlorin	6.808	28.033	Sodic Sulfate	18.217	75.018
Sodic Oxid	16.904	69.612	Sodic Chlorid	11.230	46.246
Potassic Oxid	0.088	0.361	Sodic Carbonate	4.781	19.687
Calcic Oxid	10.824	44.572	Sodic Silicate	0.368	1.515
Magnesic Oxid	10.330	42.539	Ferric and Al. Oxids	0.036	0.149
Ferric and Al. Oxids	0.036	0.149	Manganic Oxid	0.082	0.339
Manganic Oxid	0.082	0.339	Ignition	8.140	33.521
Ignition	8.140	33.521			
Sum	101.992	419.716	Sum	100.299	413.034
Oxygen Equiv. to Chlorin	1.534	6.319	Excess Silicic Acid	0.084	0.346
Total	100.388	413.397	Total	100.383	413.380

Total Solids, 411.8 grains per imperial gallon.
* After irrigation.

§ 59. We probably applied eight inches of water in this irrigation and had a very small off-flow, so small that it may be neglected in any estimate of the changes produced by the application of the water. The whole eight inches may, in this case, be regarded as having entered the soil and as resting for the time-being upon the water plane as it stood before irrigation. That this is not correct is evident from what we have observed to be the effect of a comparatively small rainfall upon the height of the

water plane. Further, there must be a rapid diffusion of salts taking place between the two solutions represented by the ground water, which probably moves upward when the surface is first moistened, and the descending irrigation water. This diffusion may be greatly modified by the soil, but that some diffusion takes place can not be doubted.

§ 60. I see no better way to present the general changes than to compare the ground water as actually found before and after irrigation. This varied in the different wells under observation; it is usually a difference of degree rather than of character. While I know that in some respects I do violence to the facts from minor points of view, I think that by taking the averages of results found, we obtain a faithful view of the general results for the given irrigation and, while this does not answer many questions which arise, it seems the best approach that we can make to a knowledge of what takes place. As we estimate the amount of water applied at the rate of eight inches or two-thirds of an acre-foot, we will make our calculations for this amount throughout. The irrigation was begun on the 8th and the samples taken on the 11th instant and, as we know that some diffusion must have taken place in these three days, we will assume that this took place completely with an equivalent of eight inches of the ground water.

§ 61. The two-thirds acre-foot of irrigation water contained a total of 1,297 pounds of salts in solution; a like quantity of ground water before irrigation contained 5,139 pounds of salts and after irrigation, 9,550 pounds. The ground water as it was taken from the wells after irrigation showed an increase of 4,411 pounds in the salts held in each eight inches of water. If, however, we had mixed eight inches of the irrigation water with a like quantity of the ground water before irrigation, each eight inches should have contained 3,218 pounds. But we find 9,550 pounds which is an excess of 6,332 pounds in each eight inches, representing the actual solution of 12,664 pounds of salts, which is probably nearer correct than the 4,411 pounds. But as we wish to present conservative figures, we adopt the latter and assume that the eight inches of irrigation water applied, dissolved from the soil 4,411 pounds of salts which were previously not in solution. It would, however, be better to say that the result of the irrigation was to set this much salt free, that is, that whatever reactions may have been induced between the salts within the soil, resulted in bringing this additional amount into solution in the ground water. That the irrigation water acts not merely as a diluent is proven by the changed ratio of the salts present, which is best presented as follows:

TOTAL SOLIDS IN GROUND WATER BEFORE AND AFTER IRRIGATION, JUNE 27—JULY 11, 1898.

Ground Water.	*Before Irrigation.*	*After Irrigation.*	*Pounds Gain.*
Total Solids	5,139.0	9,550.0	4,411.0
Calcic Sulfate	1,860.2	2,750.4	890.2
Magnesic Sulfate	1,238.5	2,473.5	1,235.0
Sodic Sulfate	698.9	3,129.7	1,430.8
Sodic Carbonate	421.4	515.7	94.3
Sodic Chlorid	560.2	916.8	357.6
Organic Matter, etc.	360.8	763.9	403.1
Total	5,139.0	9,550.0	4,411.0

§ 62. This table is probably too conservative, but it serves to show that in this soil the solution of sodic and magnesic sulfates takes place in a far greater degree than does that of the other salts. The amount of potassic oxid held in solution or involved in the changes produced by irrigation does not seem to be very significant. The average amount of potassic oxid extracted from this soil by a five days' digestion with dilute hydrochloric acid, 1.115 specific gravity, is 1.25 per cent., or in an acre-foot of soil, taking its weight as 3,500,000, we have 43,750 pounds and the total potassic oxid in this soil is about 2.25 per cent., or 78,750 pounds per acre. I have pointed out elsewhere that there is an abundance of felspar in this soil and also that dilute hydrochloric acid acts very perceptibly upon it, as do also water and carbonic acid. The amount of potassic oxid contained in the ground water before irrigation amounted to 16.6 pounds in each eight inches of water per acre, and after irrigation, 31.7 pounds, an increase of 91 per cent., or 15.1 pounds. This quantity is apparantly not very significant either as an absolute quantity or in comparison with that soluble in dilute hydrochloric acid but there is a view in which it may be significant. A crop of beets of 14 tons to the acre would at maturity contain about 120 or 125 pounds of potassic oxid, or including the tops, 240 to 250 pounds. This represents the season's gathering by the plants, but the application of eight inches of water has in three days involved an eighth of the quantity used by the roots, and one-sixteenth of that used by the whole crop in changes whereby it has passed into solution in the ground water; it may be a case of simple solution, or the solution may have been preceded by other chemical changes, which seems exceedingly probable.

§ 63. In 1899 we had a very much better supply of water which we obtained through the kindness of Water Commissioner C. C. Hawley; this was water taken from the Poudre but it was impossible to prevent the inter-mixing of some seepage water of which we shall give as full an account as is required without endeavoring to give too many details. The facts concerning these waters will appear from the analyses with sufficient fullness and further explanations would be tedious to the reader.

TABLE XXII.—WATER USED IN IRRIGATING, SEPT. 1, 1899.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silcic Acid	3.172	0.729
Sulfuric Acid	28.578	6.559
Carbonic Acid	14.493	3.332
Chlorin	3.221	0.741
Sodic Oxid	17.371	3.995
Potassic Oxid	1.298	0.299
Calcic Oxid	18.172	4.180
Magnesic Oxid	5.597	1.287
Ferric and Al. Oxids	0.318	0.073
Manganic Oxid	0.259	0.060
Ignition	8.205	1.887
Sum	100.624	23.142
Oxygen Eq. to Cl.	0.726	0.167
Total	99.898	22.975

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	44.112	10.146
Magnesic Sulfate	3.866	0.889
Magnesic Chlorid	4.312	0.992
Magnesic Carbonate	5.230	1.203
Potassic Carbonate	1.904	0.438
Sodic Carbonate	26.881	6.183
Sodic Silicate	3.227	0.742
Ferric and Al. Oxids	0.318	0.073
Manganic Oxid	0.259	0.060
Ignition	8.205	1.887
Sum	98.314	22.613
Excess Silicic Acid	1.583	0.364
Total	99.897	22.977

Total solids, 23.0 grains per imperial gallon.

TABLE XXIII.— SEEPAGE WATER FROM MERCER DITCH USED IN IRRIGATING, SEPT. 2, 1899.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.971	0.976
Sulfuric Acid	35.945	17.793
Carbonic Acid	10.989	5.440
Chlorin	3.381	1.674
Sodic Oxid	18.296	9.056
Potassic Oxid	0.641	0.317
Calcic Oxid	17.804	8.813
Magnesic Oxid	5.733	2.838
Ferric and Al. Oxids	0.478	0.236
Manganic Oxid	0.159	0.079
Ignition	5.322	2.634
Sum	100.719	49.856
Oxygen Eq. to Cl.	0.762	0.377
Total	99.957	49.479

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	43.219	21.393
Magnesic Sulfate	15.793	7.818
Magnesic Chlorid	1.114	0.551
Potassic Chlorid	1.014	0.502
Sodic Chlorid	3.411	1.688
Sodic Carbonate	26.498	13.117
Sodic Silicate	19.923	0.952
Ferric and Al. Oxids	0.478	0.236
Manganic Oxid	0.159	0.079
Ignition	5.322	2.634
Sum	98.931	48.970
Excess Silicic Acid	1.024	0.507
Total	99.955	49.477

Total solids, 49.5 grains per imperial gallon.

TABLE XXIV—OFF-FLOW, N. SIDE SEPT. 2, 1899; 1st SAMPLE. *

Analytical Results.	*Per Cent*	*Grs. Imp. Gal.*
Silicic Acid	0.688	0.597
Sulfuric Acid	42.183	36.615
Carbonic Acid	6.432	5.583
Chlorin	3.755	3.259
Sodic Oxid	17.140	14.878
Potassic Oxid	1.118	0.970
Calcic Oxid	14.998	13.018
Magnesic Oxid	7.418	6.439
Ferric and Al. Oxids	0.050	0.043
Manganic Oxid	0.050	0.043
Ignition	6.981	6.060
Sum	100.813	87.505
Oxygen Eq. to Cl.	0.846	0.734
Total	99.967	86.771

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	36.408	31.602
Magnesic Sulfate	22.259	19.321
Potassic Sulfate	2.059	1.787
Sodic Sulfate	8.862	7.692
Sodic Chlorid	6.197	5.379
Sodic Carbonate	15.509	13.462
Sodic Silicate	1.397	1.212
Ferric and Al. Oxids	0.050	0.043
Manganic Oxid	0.050	0.043
Ignition	6.981	6.060
Sum	99.772	86.601
Excess Sodic Oxid	0.194	0.168
Total	99.966	86.769

Total solids, 86.8 grains per imperial gallon.

* Sample taken at beginning of off-flow; on-flowing water was ditch water.

TABLE XXV.—OFF-FLOW E. END, SEPT. 2, 1899; 1st SAMPLE. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	2.056	0.977
Sulfuric Acid	32.472	15.424
Carbonic Acid	14.188	6.738
Chlorin	2.865	1.361
Sodic Oxid	18.675	8.871
Potassic Oxid	0.791	0.376
Calcic Oxid	18.641	8.854
Magnesic Oxid	6.116	2.905
Ferric and Al. Oxids	0.039	0.077
Manganic Oxid	0.010	0.005
Ignition	5.069	2.408
Sum	100 922	47.936
Oxygen Eq. to Cl.	0.646	0.307
Total	100.276	47.629

Combined	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	45.251	21.494
Magnesic Sulfate	8.792	4.176
Magnesic Chlorid	3.835	1.827
Magnesic Carbonate	3.294	1.565
Potassic Carbonate	1.160	0.551
Sodic Carbonate	29.162	13.852
Sodic Silicate	3.166	1.504
Ferric and Al. Oxids	0.039	0.017
Manganic Oxid	0.010	0.005
Ignition	5.069	2.408
Sum	99.778	47.399
Excess Silicic Acid	0.497	0.236
Total	100.275	47.635

Total solids, 47.5 grains per imperial gallon.

* Sample taken from the first portion of off-flow after running the full length of the plot, 600 feet.

TABLE XXVI.—OFF-FLOW N. SIDE SEPT. 2, 1899; 2nd SAMPLE. *

Analitical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	2.069	0.761
Sulfuric Acid	32.676	12 025
Carbonic Acid	14.379	5.291
Chlorin	2 578	0.949
Sodic Oxid	18.247	6 715
Potassic Oxid	0.648	0.238
Calcic Oxid	19.160	7.051
Magnesic Oxid	5.696	2.096
Ferric and Al. Oxids	0.010	0.004
Manganic Oxid	0.060	0.022
Ignition	5 076	1.868
Sum	100 599	37.020
Oxygen Eq. to Cl.	0 581	0.214
Total	100 018	36.806

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	46.511	17.116
Magnesic Sulfate	7.986	2.939
Magnesic Chlorid	3.451	1.270
Magnesic Carbonate	3.317	1.221
Potassic Carbonate	0.951	0.350
Sodic Carbonate	29.753	10.949
Sodic Silicate	1.641	0.604
Ferric and Al. Oxids	0.010	0.004
Manganic Oxid	0.060	0.022
Ignition	5.076	1 868
Sum	98.756	36.343
Excess Silicic Acid	1.261	0 464
Total	100.017	36.807

Total solids, 36.8 grains per imperial gallon.

* Sample taken just before on-flow was cut off.

TABLE XXVII.—OFF-FLOW E. END, SEPT. 2, 1899, 2nd. SAMPLE.*

Analytical Results	*Per Cent*	*Grs. Imp. Gal.*
Silicic Acid	2.725	1.150
Sulfuric Acid	34.007	14.351
Carbonic Acid	12.588	5.312
Chlorin	3.029	1.278
Sodic Oxid	18.978	8.009
Potassic Oxid	0.815	0.344
Calcic Oxid	17.709	7.473
Magnesic Oxid	5.829	2.460
Ferric and Al. Oxids	0.316	0.133
Manganic Oxid	0.010	0.004
Ignition	5.116	2.159
Sum	101.124	42.673
Oxygen Eq. to Cl.	0.682	0.288
Total	100.440	42.385

Combined.	*Per Cent*	*Grs. Imp. Gal.*
Calcic Sulfate	41.989	17.719
Magnesic Sulfate	14.588	6.156
Magnesic Chlorid	2.296	0.969
Potassic Chlorid	1.290	0.544
Sodic Chlorid	1.157	0.488
Sodic Carbonate	30.353	12.809
Sodic Silicate	1.184	0.499
Ferric and Al. Oxids	0.316	0.133
Manganic Oxid	0.010	0.004
Ignition	5.116	2.159
Sum	98.299	41.480
Excess Silicic Acid	2.142	0.904
Total	100.441	42.384

Total solids, 42.2 grains per imperial gallon.

* Sample taken just before on-flow was cut off.

TABLE XXVIII.—ANALYSIS OF WELL D, AUGUST 31, 1899. *

Analtical Results.	Per Cent.	Grs. Imp. Gal.
Silicic Acid	1.743	1.119
Sulfuric Acid	38.907	24.978
Carbonic Acid	9.398	6.034
Chlorin	3.968	2.547
Sodic Oxid	19.144	12.290
Potassic Oxid	0.142	0.091
Calcic Oxid	14.587	9.365
Magnesic Oxid	7.778	4.993
Ferric and Al. Oxids	0.079	0.051
Manganic Oxid	0.159	0.102
Ignition	5.165	3.316
Sum	101.070	64.886
Oxygen Eq. to Cl	0.892	0.572
Total	100.178	64.314

Combined.	Per Cent.	Grs. Imp. Gal.
Calcic Sulfate	35.410	22.733
Magnesic Sulfate	23.339	14.984
Potassic Sulfate	0.261	0.168
Sodic Sulfate	4.269	2.741
Sodic Chlorid	6.548	4.204
Sodic Carbonate	22.661	14.548
Sodic Silicate	1.066	0.684
Ferric and Al. Oxids	0.079	0.051
Manganic Oxid	0.159	0.102
Ignition	5.165	3.316
Sum	98.957	63.531
Excess Silicic Acid	1.218	0.782
Total	100.175	64.313

Total solids 64.2 grains per imperial gallon.
* Before irrigation.

TABLE XXIX.—ANALYSIS OF WELL D, SEPT. 2, 1899.*

Analytical Results	Per Cent	Grs. Imp. Gal.
Silicic Acid	0.460	1.211
Sulfuric Acid	52.466	138.143
Carbonic Acid	2.369	6.237
Chlorin	1.904	5.013
Sodic Oxid	13.234	34.845
Potassic Oxid	0.473	1.245
Calcic Oxid	16.635	43.800
Magnesic Oxid	9.219	24.274
Ferric and Al. Oxids	0.010	0.026
Manganic Oxid	0.030	0.079
Ignition	3.651	9.613
Sum	100.451	264.486
Oxygen Eq. to Cl.	0.429	1.129
Total	100.022	263.357

Combined.	Per Cent	Grs. Imp. Gal.
Calcic Sulfate	40.381	106.323
Magnesic Sulfate	27.663	72.837
Potassic Sulfate	0.871	2.293
Sodic Sulfate	17.540	46.183
Sodic Chlorid	3.152	8.299
Sodic Carbonate	5.712	10.040
Sodic Silicate	0.934	2.459
Ferric and Al. Oxids	0.010	0.026
Manganic Oxid	0.030	0.079
Ignition	3.651	9.613
Sum	99.944	263.152
Excess Sodic Oxid	0.074	0.198
Total	100.018	263.347

Total solids 263.3 grains per imperial gallon.
*After irrigation.

TABLE XXX.—ANALYSIS OF WELL C, AUG. 31, 1899. *

Analtical Results.	Per Cent.	Grs. Imp. Gal.
Silicic Acid	1.663	1.369
Sulfuric Acid	40.327	33.189
Carbonic Acid	7.788	6.410
Chlorin	1.557	1.281
Sodic Oxid	18.846	15.510
Potassic Oxid	0.066	0.054
Calcic Oxid	14.037	11.552
Magnesic Oxid	6.706	5.519
Ferric and Al. Oxids	0.090	0.074
Manganic Oxid	0.040	0.033
Ignition	8.931	7.350
Sum	100.051	82.341
Oxygen Eq. to Cl.	0.350	0.288
Total	99.701	82.053

Combined.	Per Cent.	Grs. Imp. Gal.
Calcic Sulfate	34.075	28.044
Magnesic Sulfate	20.122	16.560
Potassic Sulfate	0.122	0.100
Sodic Sulfate	12.107	9.964
Sodic Chlorid	2.569	2.114
Sodic Carbonate	18.775	15.452
Sodic Silicate	2.368	1.949
Ferric and Al. Oxids	0.090	0.074
Manganic Oxid	0.040	0.033
Ignition	8.931	7.350
Sum	99.199	81.640
Excess Silicic Acid	0.497	0.409
Total	99.696	82.049

Total solids 82.3 grains per imperial gallon.
* Before irrigation.

TABLE XXXI.—ANALYSIS OF WELL C. SEPT. 2, 1899. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.397	1.366
Sulfuric Acid	47.826	164.617
Carbonic Acid	2.065	7.108
Chlorin	6.483	22.314
Sodic Oxid,	21.438	73.790
Potassic Oxid	0.197	0.678
Calcic Oxid	10.527	36.234
Magnesic Oxid	8.472	29.161
Ferric and Al. Oxids	0.030	0.103
Manganic Oxid	0.060	0.206
Ignition	3.842	13.224
Sum	101.337	348.801
Oxygen Eq. to Cl.	1.461	5.029
Total	99.876	343.772

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	25.554	87.957
Magnesic Sulfate	25.422	87.503
Potassic Sulfate	0.363	1.249
Sodic Sulfate	27.848	95.853
Sodic Chlorid	10.698	36.823
Sodic Carbonate	4.979	17.138
Sodic Silicate	0.806	2.774
Ferric and Al. Oxids	0.030	0.103
Manganic Oxid	0.060	0.206
Ignition	3.842	13.224
Sum	99.602	342.830
Excess Sodic Oxid	0.272	0.936
Total	99.874	343.766

Total solids, 844.2 grains per imperial gallon.
*After irrigation.

TABLE XXXII.—ANALYSIS OF WELL B, AUGUST 31, 1899. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.838	2.474
Sulfuric Acid	42.859	57.688
Carbonic Acid	5.866	7.896
Chlorin	4.790	6.447
Sodic Oxid	19.527	26.283
Potassic Oxid	0.206	0.277
Calcic Oxid	14.082	18.954
Magnesic Oxid	7.193	9.682
Ferric and Al. Oxids	0.138	0.186
Manganic Oxid	0.069	0.093
Ignition	4.691	6.314
Sum	101.259	136.294
Oxygen Eq. to Cl.	1.079	1.452
Total	100.180	134.842

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	34.184	46.012
Magnesic Sulfate	21.584	29.052
Potassic Sulfate	0.379	0.510
Sodic Sulfate	14.552	19.587
Sodic Chlorid	7.904	10.639
Sodic Carbonate	14.144	19.038
Sodic Silicate	1.369	1.842
Ferric and Al. Oxids	0.138	0.186
Manganic Oxid	0.069	0.093
Ignition	4.691	6.314
Sum	99.014	133.273
Excess Silicic Acid	1.164	1.567
Total	100.178	134.840

Total solids 184.6 grains per imperial gallon.
* Before irrigation.

TABLE XXXIII.—ANALYSIS OF WELL B, SEPT. 2, 1899. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.048	1.555
Sulfuric Acid	43.021	63.843
Carbonic Acid	6.358	9.435
Chlorin	4.286	6.360
Sodic Oxid	19.261	28.583
Potassic Oxid	0.067	0.099
Calcic Oxid	14.454	21.450
Magnesic Oxid	7.131	10.582
Ferric and Al. Oxids	0.020	0.030
Manganic Oxid	0.040	0.059
Ignition	5.381	7.985
Sum	101.067	149.981
Oxygen Eq. to Cl.	0.966	1.433
Total	100.101	148.548

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	35.087	52.069
Magnesic Sulfate	21.398	31.755
Potassic Sulfate	0.123	0.183
Sodic Sulfate	14.221	21.104
Sodic Chlorid	7.073	10.496
Sodic Carbonate	15.331	22.751
Sodic Silicate	0.745	1.106
Ferric and Al. Oxids	0.020	0.030
Manganic Oxid	0.040	0.059
Ignition	5.381	7.985
Sum	99.419	147.538
Excess Silicic Acid	0.681	1.011
Total	100.100	148.549

Total solids, 148.4 grains per imperial gallon.
* After irrigation.

TABLE XXXIV.—ANALYSIS OF WELL A, AUG. 31, 1899. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.370	1.586	Calcic Sulfate	30.416	35.191
Sulfuric Acid	43.578	50.420	Magnesic Sulfate	27.369	31.666
Carbonic Acid	3.838	4.441	Potassic Sulfate	0.342	0.396
Chlorin	5.755	6.658	Sodic Sulfate	12.941	14.973
Sodic Oxid	17.006	19.676	Sodic Chlorid	9.497	10.988
Potassic Oxid	0.186	0.215	Sodic Carbonate	9.255	10.708
Calcic Oxid	12.530	14.497	Sodic Silicate	1.763	2.040
Magnesic Oxid	9.121	10.553	Ferric and Al. Oxids	0.110	0.127
Ferric and Al. Oxids	0.110	0.127	Manganic Oxid	0.060	0.069
Manganic Oxid	0.060	0.069	Ignition	7.751	8.967
Ignition	7.751	8.967	Sum	99.504	115.125
Sum	101.305	117.209	Excess Silicic Acid	0.502	0.581
Oxygen Eq. to Cl.	1.297	1.501	Total	100.006	115.706
Total	100.008	115.708			

Total solids 115.7 grains per imperial gallon.
*Before irrigation.

TABLE XXXV.—ANALYSIS OF WELL A, SEPT. 2, 1899. *

Analytical Results	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.907	1.486	Calcic Sulfate	32.552	53.320
Sulfuric Acid	45.097	73.869	Magnesic Sulfate	27.354	44.806
Carbonic Acid	4.720	7.731	Potassic Sulfate	0.175	0.287
Chlorin	4.621	7.569	Sodic Sulfate	13.546	22.188
Sodic Oxid	16.900	27.672	Sodic Chlorid	7.626	12.491
Potassic Oxid	0.095	0.156	Sodic Carbonate	11.381	18.642
Calcic Oxid	13.407	21.964	Sodic Silicate	0.552	0.914
Magnesic Oxid	9.116	14.932	Ferric and Al. Oxids	0.040	0.065
Ferric and Al. Oxids	0.040	0.065	Manganic Oxid	0.030	0.049
Manganic Oxid	0.030	0.049	Ignition	5.999	9.826
Ignition	5.999	9.826	Sum	99.255	162.588
Sum	100.932	165.329	Excess Silicic Acid	0.635	1.040
Oxygen Eq. to Cl.	1.041	1.705	Total	99.890	163.628
Total	99.891	163.624			

Total solids 163.8 grains per imperial gallon.
*After irrigation.

SANITARY ANALYSES OF IRRIGATION WATERS, AUGUST 31 TO SEPTEMBER 2, 1899.

1. Ditch water as it flowed onto the plot. Sept. 1, 1899.
2. Seepage water as it flowed onto the plot.
3. Water as it flowed off at north side of plot. Sept. 2, 1899. Beginning of off-flow.
4. Water as it flowed off at east end of plot. Sept. 2, 1899. Beginning of off-flow.
5. Water as it flowed off at north side of plot. End of off-flow.
6. Water as it flowed off at east end of plot. End of off-flow.
7. Water of well A. August 31, 1899. Before irrigation.
8. Water of well B. August 31, 1899. Before irrigation.
9. Water of well C. August 31, 1899. Before irrigation.
10. Water of well D. August 31, 1899. Before irrigation.
11. Water of well A. September 2, 1899. After irrigation.
12. Water of well B. September 2, 1899. After irrigation.
13. Water of well C. September 2, 1899. After irrigation.
14. Water of well D. September 2, 1899. After irrigation.

SANITARY ANALYSES OF WATER BEFORE AND AFTER IRRIGATION.

PARTS PER MILLION.

	Total Solids	Chlorin	Nitrates		Nitrites		Ammonia		Albuminoidal Ammonia		Oxygen Consumed
			Nitrogen	Nitric Acid	Nitrogen	Nitrous Acid	Nitrogen	Ammonia	Nitrogen	Ammonia	
1	328.5	9.40	Trace	Trace	0.4400	1.6780	0.3180	0.3860	0.3880	0.4100	4.625
2	707.1	15.80	Trace	Trace	0.0700	0.2840	0.1820	0.2210	0.3140	0.3825	4.450
3	1240.0	50.70	0.440	1.970	0.1400	0.4600	0.3160	0.3840	0.5540	0.6720	7.740
4	678.5	27.10	0.240	1.077	0.2600	0.3700	0.0560	0.0680	0.2490	0.3020	3.875
5	525.7	17.10	Trace	Trace	0.1100	0.3680	0.0680	0.0765	0.3540	0.4290	4.555
6	602.8	18.70	0.080	0.359	0.1000	0.3348	0.0840	0.1020	0.3420	0.4150	5.720
7	1652.8	76.80	0.440	1.970	0.0025	0.0088	0.0820	0.0888	0.2500	0.3029	
8	1922.8	99.50	0.480	2.154	0.0008	0.0010	0.0190	0.0230	0.0950	0.1147	
9	1175.8	57.40	0.560	2.513	0.0025	0.0084	0.0220	0.0267	0.0560	0.0674	
10	917.1	43.10	0.600	2.692	0.0250	0.0837	0.0700	0.0850	0.0860	0.1088	
11	2840.0	103.10	0.720	3.231	0.0025	0.0084	0.0470	0.0570	0.2260	0.2740	
12	2120.0	103.40	0.440	1.970	0.0060	0.0200	0.0600	0.0788	0.1480	0.1780	
13	4917.1	374.30	1.700	7.628	0.0300	0.1000	0.4760	0.5780	2.5680	3.1170	
14	3761.4	107.70	0.360	1.605	0.0900	0.1090	0.4120	0.5000	2.3000	2.7920	

§ 64. We had, as already stated, a good supply of water and can therefore make our calculations on the basis of an acre-foot and approximate closely to the results actually produced. As it was impossible to determine with any approach to accuracy the amount of seepage water which got mixed with the ditch water before it reached the plot, I will neglect it in our estimate but will state separately the amount of salts carried by the seepage as we collected it. The results so far as the amount and character of the salts in the ground water will not be affected thereby.

§ 65. The ditch water carried total solids to the amount of more than twice as much as I have ever found in Poudre water at, or rather a little below, the point where this water was taken out. But I have already pointed out the fact that the Poudre water increases materially in the amount of total solids held in solution from a point just above the mouth of the North Fork to a point below Bellvue, a distance of less than eight miles. The maximum increase observed at a period of low water was about four times the amount contained at the higher point. It is not a matter of surprise then that there should be still greater increase after it has flowed through a cultivated section, for a little more than four miles. This water carried 894.5 pounds of total solids in each acre-foot and the salts represented were not present in the proportions usually found. They were calcic sulfate, 393.6; magnesic sulfate, very little or none; sodic carbonate 239.6 and potassic oxid (K_2O) 11.6 pounds.

§ 66. An acre-foot of the seepage water as it was gathered at the time, carried 1,925 pounds of total solids, but as we do not know the amount of this water flowing in at the time, we cannot make any correction for it. The relative amount was certainly not as much as one-fourth and the weights of salts subsequently dealt with being large and only approximate at best, the seepage water can justly be neglected. The salts held in solution show clearly that it is properly classed as seepage water though evidently mixed with ditch water which had run over the surface of the meadow along the edge of which our lateral ran. These salts were, according to our manner of combining the analytical results, as follows; calcic sulfate, 828.0; magnesic sulfate, 304.0; sodic carbonate, 511.6; potassic oxid (K_2O) 12.4 pounds per acre-foot.

§ 67. The ground water before and after irrigation carried the following quantities of total solids composed of the salts given herewith:

TOTAL SOLIDS IN GROUND WATER AUG. 31.—SEPT. 2, 1899, PER ACRE-FOOT.

	Before Irrigation.	*After Irrigation.*	*Pounds Gain.*
Total Solids	3,868.0	8,809.0	4,941.0
Calcic Sulfate	1,303.5	2,942.2	1.638.7
Magnesic Sulfate	893.5	2,237.5	1,344.0
Sodic Sulfate	425.5	1,612.0	1,186.5
Sodic Carbonate	543.0	740.0	197.0
Sodic Chlorid	255.3	616.6	361.3
Organic Matter, etc.	447.2	660.7	213.5
Total	3,868.0	8,809.0	4,941.0

§ 68. This shows an increase in the total solids contained in each acre-foot of ground water of 4,941 pounds, but if we con-

sider, as suggested in the observations made on the irrigation of 1898, that the ground water as taken after irrigation represents a mixture of equal parts of irrigation water and ground water we find that to produce this change in the amount of total solids 12,856 pounds of salts must have passed into solution.

§ 69. For the experiment of 1898 we found that 4,411 pounds went into solution or, assuming a mixing to the extent of equal parts, 12,664 pounds per acre-foot; for 1899 we have 4,941 pounds and 12,856. When we attempt to find how this gain was distributed between the different salts we find the same order, namely sodic sulfate, magnesic sulfate and calcic sulfate. In 1899, however, the calcic sulfate shows a greater increase than in 1898. This is accounted for by the influence of well D, which in 1898 could not be included, because being near the point of onflow it was not looked after as carefully as it should have been, and the water getting advantage of us ran into the well from the surface. In 1898 the percentage of calcic sulfate in the residue from the ground water was lower after irrigation than before, except in the case of well D, which showed an increase of five per cent. The result is probably correct and represents what actually took place, but it is contrary to our observations. While it modifies our general results, it does not reverse them.

§ 70. The potassic oxid in an acre-foot of the ditch water used was only 11.6 pounds, in the ground water before irrigation 5.8 pounds, in the ground water after irrigation 18.3 pounds, or if we consider the ground water after irrigation as representing a mixture of equal parts, as before, we have 19.2 pounds of potassic oxid brought into solution by the application of an acre-foot of water.

§ 71. The water that flowed over and off of the plot was not large in quantity but we collected samples as near the beginning and end of off-flow as was feasible. The salient features of the results will be seen upon an examination of the analyses.

§72. The off-flow took place at two points, one near the center of the north side of the plot, the other at the east end, the water flowing from west to east.

§ 73. The samples obtained of the off-flow on the north side showed a very marked difference in the quantity of total solids present in the first and second samples. The first sample contained 3,390, the second 1,431 pounds per acre-foot. The sample taken at the east end of the plot showed the same fact but much less markedly; the first sample containing 1,847, the second 1,641 pounds per acre-foot. This difference is accounted for, I think, by the fact that we failed to get the first portion of the off-flow at the east end, while we succeeded in getting it at the north side. The decrease in the total salts carried in solution by such water is

very rapid at first and gradually becomes slower which fully explains the differences observed in these two sets of samples. It is evident from what I have said, relative to the amount of off-flow and the fact that it was only by the courtesy of the water commissioner that we obtained this water, that we did all that we could with this subject. When we consider that this water on leaving the plot after flowing over it for 600 feet had only washed off and dissolved out between 800 and 1,000 pounds of salts per acre-foot, under very favorable conditions, and that the rate of action decreases rapidly it would seem to indicate that long continued flooding with off-flow would not be an advisable proceedure in order to remove salts from the soil.

§ 74. There is one thing suggested by the analyses, i. e., that in the case of long continued flooding the amount of potash removed might become a matter worthy of consideration. The percentage of this substance present in the residue from the off-flowing waters is not so high as in the residue obtained from the waters applied, but when the increase in the total solids is taken into consideration it indicates a probable loss of this substance. Our data is not adequate to justify general conclusions on this subject. My opinion, however, is that the loss is less serious than one would be inclined to think, judging from the results shown by these samples.

§ 75. The sanitary analyses show the same facts relative to the total solids and chlorin, but they are given in terms of parts per million, instead of grains per gallon. In the total solids we discover an extreme quantity in the well waters after irrigation, equal to 13 times the quantity in the water used for irrigating, and over four times the amount found in the same well before irrigation. The chlorin is 40 times greater in the well water after irrigation than in the ditch water applied, and between six and seven times greater than in the same well before irrigation. The principal object in making the sanitary analyses was to determine the different forms and quantities in which nitrogen was present. The quantities found, even when taken together, are scarcely worth considering so far as their fertilizing value is concerned. The ditch water used in 1899 contained in all forms almost three pounds of nitrogen per acre-foot. The soil to which this water was applied contained in the first foot of soil 3,500 pounds. The three pounds of nitrogen, if it were present as potassic nitrate, would be insignificant, but the analysis shows that none of it was present as nitric acid. This ditch water shows the presence of more nitrous acid than any sample analyzed in connection with the work.

§ 76. The seepage water that mingled with the ditch water was even poorer in nitrogen than the ditch water, so the water

used in this irrigation literally vanishes as a factor in any question pertaining to nitrogen.

§ 77. The nitrates, or rather the corresponding nitric acid in the ground water before and after irrigation, does not show changes on the scale I anticipated. An acre-foot of ground water before irrigation contained 6.413 pounds of nitric acid, as nitrates, and after irrigation 9.861 pounds, which correspond roughly to 2.2 pounds of nitrogen, a wholly insignificant amount from any practical standpoint. The amount is not only small but it must also be considered that at least three and one-half feet of soil have probably been involved in producing this result. Whatever reactions may have taken place, the elimination, or the passing of the nitrates into a free solution, has taken place to a very small extent.

§ 78. Nitrous acid is present, both before and after irrigation, in such small quantities that a much more extended and careful investigation would be required to justify even a tentative interpretation. The quantity present after, is greater than before irrigation, but the quantity present in either case is small, not a tenth of that present in the ditch water.

§ 79. In the spring of 1900 we had an exceptionally heavy precipitation, snow and rain. Beginning March 27, we had 3.5 inches of snow; on the 30th, a little rain, and from April 4 to 9 inclusive, rain or snow daily. During this time we had 12 inches of snow fall, and a total of 4.2 inches of water. This differs materially from an irrigation of 4.2 inches, the whole surface of adjacent land receiving the same amount of water which, I consider, influences the water plane materially, either by movement or pressure. The water plane in this case was brought up to within a few inches of the surface. This may have been the result of water from the adjoining lands. The snow which melted slowly, and to which there was a daily addition of from .2 to .4 inches of rainfall at this time, gave the water opportunity to enter the soil slowly and over the whole area at the same time. Samples of well A were taken April 9 and 17, 1900, when the water plane was perhaps at its highest point, the analysis of which resulted as follows:

TABLE XXXVI.—ANALYSIS OF WELL A, APR. 9, 1900.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.271	1.965
Sulfuric Acid	45.332	328.657
Carbonic Acid	1.383	10.027
Chlorin	8.931	64.749
Sodic Oxid	18.936	137.286
Potassic Oxid	0.158	1.146
Calcic Oxid	6.893	49.974
Magnesic Oxid	12.046	87.333
Ferric and Al. Oxids	0.050	0.363
Manganic Oxid	0.060	0.435
Ignition	8.206	59.493
Sum	102.266	741.428
Oxygen Eq. to Cl.	2.012	14.587
Total	100.254	726.841

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	16.733	121.314
Magnesic Sulfate	36.146	262.059
Potassic Sulfate	0.291	2.110
Sodic Sulfate	19.993	144.949
Sodic Chlorid	14.738	106.850
Sodic Carbonate	3.335	24.179
Sodic Silicate	0.550	3.987
Ferric and Al. Oxids	0.050	0.363
Manganic Oxid	0.060	0.435
Ignition	8.206	59.493
Sum	100.102	725.739
Excess Sodic Oxid	0.148	1.073
Total	100.250	726.812

Total solids 725.0 grains per imperial gallon.

TABLE XXXVII.—ANALYSIS OF WELL A, APRIL 17, 1900.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.284	1.285
Sulfuric Acid	45.565	206.090
Carbonic Acid	2.347	10.615
Chlorin	7.554	34.167
Sodic Oxid	20.108	90.948
Potassic Oxid	0.087	0.394
Calcic Oxid	6.934	31.362
Magnesic Oxid	11.236	50.820
Ferric and Al. Oxids	0.030	0.136
Manganic Oxid	0.030	0.136
Ignition	7.618	34.456
Sum	101.793	460.409
Oxygen Eq. to Cl.	1.702	7.698
Total	100.091	452.711

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	16.832	76.131
Magnesic Sulfate	33.716	152.497
Potassic Sulfate	0.160	0.724
Sodic Sulfate	23.286	105.323
Sodic Chlorid	12.466	56.384
Sodic Carbonate	5.659	25.596
Sodic Silicate	0.016	0.072
Ferric and Al. Oxids	0.030	0.136
Manganic Oxid	0.030	0.136
Ignition	7.618	34.456
Sum	99.813	451.455
Excess Silicic Acid	0.276	1.248
Total	100.089	452.703

Total solids 452.8 grains per imperial gallon.

TABLE XXXVIII.—ANALYSIS OF WELL G, APRIL 17, 1900.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.285	1.310
Sulfuric Acid	44.885	211.049
Carbonic Acid	1.964	9.235
Chlorin	8.216	38.632
Sodic Oxid	18.741	88.120
Potassic Oxid	0.359	1.688
Calcic Oxid	10.107	47.523
Magnesic Oxid	9.731	45.755
Ferric and Al. Oxids	0.040	0.188
Manganic Oxid	0.010	0.047
Ignition	7.534	35.425
Sum	101.872	479.002
Oxygen Eq. to Cl.	1.851	8.703
Total	100.021	470.299

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	24.535	115.364
Magnesic Sulfate	29.200	137.298
Potassic Sulfate	0.655	3.080
Sodic Sulfate	18.980	89.244
Sodic Chlorid	13.558	63.750
Sodic Carbonate	4.736	22.268
Sodic Silicate	0.579	2.722
Ferric and Al. Oxids	0.040	0.188
Manganic Oxid	0.010	0.047
Ignition	7.534	35.425
Sum	99.827	469.386
Excess Sodic Oxid	0.192	0.903
Total	100.019	470.289

Total solids 470.2 grains per imperial gallon.

§ 80. The sample of water taken April 9, 1900, well A, just before the end of an unusually heavy and protracted rainfall, whereby the ground was filled with water, contains in an acre-foot of water 28,197 pounds of salts. The water of this well is usually high, therefore to obtain a better idea of what the actual increase is, I have computed the average amounts of sulfates in this water as given for 11 samples taken in 1898. When the water was low in this well the total solids were also low. In November, 1898, there were 164 grains per gallon.

WATER OF WELL A.

	April 9, 1900.	*Average for 1898.*
Total solids in an acre-foot	28,197 pounds	8,899 pounds
Calcic Sulfate	4,708 pounds	3,115 pounds
Magnesic Sulfate	10,179 pounds	2,492 pounds
Sodic Sulfate	5,639 pounds	979 pounds

§ 81. The sample of water, well A, taken eight days later, serves to show how rapidly the total solids fell at this time. The water plane had in meantime fallen about 0.8 of a foot. The total solids in an acre-foot have fallen from 28,197 to 17,722 pounds, a difference of about 10,000 pounds. Further, the salts remaining in solution have another ratio. On April 9, the calcic to the magnesic to the sodic sulfate stood roughly as 1 : 2 : 1, but on the 17th inst. they stood as 1 : 5 : 3½, from which it appears that the calcic sulfate has receded to the greatest extent, magnesic sulfate next and the sodic sulfate in the least measure.

§ 82. Well G is near well A but is a shallower well and its waters are separated from those in an underlying stratum of gravel as explained in a former bulletin. This sample perhaps represents the water in the soil more faithfully than does the water of well A, but in the main it presents the same general features, the relative quantity of the salts being a little different and their total quantity a little higher.

§ 83. Other samples of water were taken from these wells one month later, when the water plane had fallen 16 inches. These samples show 142.5 grains total solids for well A, a decrease of 582.5 grains; and 379 for well G, a decrease of 91 grains per gallon. The percentage of calcic sulfate had materially increased in well A, but only slightly in G; that of the magnesic sulfate was about the same, while the percentage of sodic sulfate had decreased in each case.

§ 84. We have more potassic oxid in the water from well G than in that from well A. In the latter we have 44.5 pounds, in the former 63.6 pounds per acre-foot, neither of them being very large quantities; the smaller being scarcely 10 times as much as water dissolves from finely divided felspar in a few days.

§ 85. These experiments indicate that either simple solution of salts, feebly held in the soil, takes place on a large scale, or else

a series of reactions whereby these salts pass into solution when the soil is supplied with an abundant quantity of water; but the relative quantities that go into solution vary, and the ratios in which the salts are present are not those of their solubilities.

THE DRAIN WATERS.

§ 86. There was no drain through the plot of ground at the time the irrigation experiments were made, so I can not give analyses of drain waters which are strictly comparable to the waters used in irrigation. I regret this but I could not do better than to take drain water from another point, which I did. This plot was subsequently drained and an analysis of the water from this drain will be given later. The first sample of drain water which I shall give was taken April 20, 1900, three days later than the last sample of well water given, and is fairly comparable to these, though taken at some distance below the plot where the wells were dug.

TABLE XXXIX.—ANALYSIS OF DRAIN WATER, APR. 20, 1900.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.816	0.963	Calcic Sulfate	40.406	45,982
Sulfuric Acid	40.284	45.843	Magnesic Sulfate	21.260	24.194
Carbonic Acid	8.537	9.715	Potassic Sulfate	0 145	0.165
Chlorin	3.939	4.483	Sodic Sulfate	4.052	4.611
Sodic Oxid	17.304	19.692	Sodic Chlorid	6.500	7 397
Potassic Oxid	0.079	0.090	Sodic Carbonate	20 585	23.426
Calcic Oxid	16.645	18.941	Sodic Silicate	0.071	0 081
Magnesic Oxid	7.085	8.063	Ferric and Alu. Oxids	0.050	0.057
Ferric and Al. Oxids	0.050	0.057	Manganic Oxid	0 060	0.068
Manganic Oxid	0.060	0.068	Ignition	6.379	7.259
Ignition	6.379	7.259	Sum	99.508	113.240
Sum	101.208	115.174	Excess Silicic Acid	0.811	0.923
Oxygen Eq. to Cl.	0.887	1.009	Total	100.319	114.163
Total	100.321	114.165			

Total solids, 118.8 grains per imperial gallon.

§ 87. This sample was taken from a new drain which was being laid beside an old one. The gravel at this time was full of water as is, so far as I know, always the case. This is the same stratum of gravel mentioned in another place, also in former bulletins, as underlying my beet plot. A comparison of the preceding analysis with one of water taken from this gravel under the beet plot, shows a general similarity, but with some differences, the most striking of which is in regard to the sodic sulfate, which is much more abundant in the water taken directly from the gravel than in the drain water. In this connection I would repeat what I have said in Bulletin No. 72, page 33, that the ground and drain waters are not alike; that the total solids decrease with the depth from which the sample is taken, and that while sodic sulfate is abundant in the ground waters, it is not so

in the drain waters. We have in this case an illustration in point. The ground waters taken three days previously showed the presence of 452 and 470 grains total solids per imperial gallon; the above drain water showed 113.8 grains. The ground waters showed respectively 105 and 89 grains of sodic sulfate per gallon, the drain water 4.6 grains, which in proportion is very greatly less, the sodic sulfate amounting to one-fourth of the total in the case of ground water, represented by well A, and 1-24 in that of the drain water; the magnesic sulfate remaining relatively constant, one-third in the well waters and one-fifth in the drain water. The calcic sulfate, on the contrary constitutes 1-6 and 1-5 respectively of the total solids in the two well waters and 2-5 of those in the drain water. I unfortunately do not know even approximately the volume of drainage water, but it is evident that the ratios in which the various salts are removed are wholly different from these in which they are found in the ground water.

§ 88. The following analyses of drain waters establish and strengthen these statements and show that the drain waters are much more nearly constant in composition than the ground waters, and vary much less in the quantity of total solids that they contain.

TABLE XL—ANALYSIS OF DRAIN WATER, JULY 23. 1900.

Analytical Results	*Per Cent*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent*	*Grs. Imp. Gal.*
Silicic Acid	1.405	1.030	Calcic Sulfate	45.265	33.179
Sulfuric Acid	42.442	31.110	Magnesic Sulfate	23.633	17.323
Carbonic Acid	7.847	5.752	Potassic Sulfate	0.147	0.108
Chlorin	3.782	2.772	Potassic Chlorid	0.055	0.040
Sodic Oxid	14.663	10.748	Sodic Chlorid	6.198	4.543
Potassic Oxid	0.115	0.084	Sodic Carbonate	18.921	13.869
Calcic Oxid	18.647	13.668	Sodic Silicate	0.589	0.432
Magnesic Oxid	7.876	5.773	Ferric and Al. Oxids	0.040	0.029
Ferric and Al. Oxids	0.040	0.029	Manganic Oxid	0.040	0.029
Manganic Oxid	0.040	0.029	Ignition	4.073	2.985
Ignition	4.073	2.985	Sum	98.961	72.537
Sum	100.930	73.980	Excess Silicic Acid	1.115	0.817
Oxygen Eq. to Cl.	0.852	0.624	Total	100.076	73.354
Total	100.078	73.356			

Total Solids, 78.8 grains per imperial gallon.

TABLE XLI.—ANALYSIS OF DRAIN WATER, MRS. CALLOWAY'S RANCH, JULY 23, 1900.

Analytical Results.	Per Cent.	Grs. Imp. Gal.
Silicic Acid	1.425	0.886
Sulfuric Acid	40.202	25.006
Carbonic Acid	9.549	5.939
Chlorin	3 635	2.261
Sodic Oxid	18.070	11.239
Potassic Oxid	0.115	0.072
Calcic Oxid	18.428	11 462
Magnesic Oxid	6.003	3.734
Ferric and Al. Oxids	0.050	0.031
Manganic Oxid	0.080	0.050
Ignition	3 405	2.118
Sum	100.962	62.798
Oxygen Eq. to Cl.	0 819	0 509
Total	100.143	62.289

Combined.	Per Cent.	Grs. Imp. Gal.
Calcic Sulfate	44.734	27.824
Magnesic Sulfate	18.013	11.204
Potassic Sulfate	0.212	0.132
Sodic Sulfate	3.177	1.976
Sodic Chlorid	5.998	3.731
Sodic Carbonate	23.025	14.322
Sodic Silicate	0.047	0.029
Ferric and Al. Oxids	0.050	0.031
Manganic Oxid	0 080	0.050
Ignition	3.405	2.118
Sum	98.741	61.417
Excess Silicic Acid	1.402	0.872
Total	100.143	62.289

Total solids 62.2 grains per imperial gallon.

TABLE XLII—ANALYSIS OF DRAIN WATER, BEET PLOT, FEB. 23, 1903.

Analytical Results.	Per Cent.	Grs. Imp. Gal.
Silicic Acid	0.812	1.302
Sulfuric Acid	49.143	78.825
Carbonic Acid	2.955	4.632
Chlorin	3.545	5.686
Sodic Oxid	12.231	19.618
Potassic Oxid	0.191	0.306
Lithic Oxid	0.033	0.053
Calcic Oxid	18.141	29.098
Strontic Oxid	0.287	0.460
Magnesic Oxid	8.822	14.150
Ferric and Al. Oxids	0.075	0.120
Manganic Oxid	0.030	0.048
Ignition	4.512	7.237
Sum	100.777	161.535
Oxygen Eq. to Cl.	0.799	1.282
Total	99.978	160.253

Combined.	Per Cent.	Grs. Imp. Gal.
Calcic Sulfate	44.033	70.631
Strontic Sulfate	0.508	0.815
Magnesic Sulfate	26.310	42.201
Potassic Sulfate	0.353	0.566
Sodic Sulfate	9.572	15.354
Sodic Chlorid	5.712	9.162
Lithic Chlorid	0.092	0.148
Sodic Carbonate	7.115	11.371
Sodic Silicate	1.646	2.640
Ferric and Al. Oxids	0.075	0.120
Manganic Oxid	0.030	0.048
Ignition	4.512	7.237
Sum	99.988	160.293
Excess	None	None
Total	99.988	160.293

Total solids 160.4 grains per imperial gallon.

§ 89. These drain waters present as great a variety as I would probably have obtained had I taken a great number from other localities. I hope and think that they represent such drain waters as we have in this section of Colorado. An examination of them shows that they contain relatively considerably more sodic carbonate than the ground waters, but less potassic salts.

§ 90. The drain on Mrs. Calloway's ranch is 500 feet long, four feet deep at its upper end, nine feet at the lower and has been open for some years. The rainfall during March, April and May of the year 1900 amounted to 13.38 inches, and the sample being taken July 23rd, was taken subsequently to the irrigation, if any were applied, which was probably the case, though I have no specific information on this point. Such were the conditions pre-

ceding the taking of the sample and they also apply to the sample taken from the drain east of the beet plot.

§ 91. The sample taken from the drain underlying the beet plot in 1903 ought to be the nearest representative of the ground waters, analyses of which have been given. This drain was not laid at the time the samples of the ground water were taken. This sample ought to represent the drain water from this plot of ground. There had been but little or no rain for some time, the surface ground was frozen and the sample was taken on this date, Feb. 23, because we feared that a thaw might set in and we would have to wait a long time and perhaps never obtain a more representative drain water than that which we were then able to procure. The presence of strontic and lithic oxids in this analysis is what we would expect from what has been said in connection with the river water. They have been found present whenever tested for, but being of subordinate importance they were not determined in the other samples, the one being included with the lime and the other with the sodic oxid.

§ 92. The potassic oxid found in the ground waters varied from 0.01 of one per cent. of the total solids to 1.2 per cent., with an average of 0.262 for the 92 samples averaged; whereas the average for the drain waters is 0.125 per cent., which calculated per acre-foot of water gives 20.7 pounds in the ground water to 5.0 pounds in the drain water. From the point of its fertilizing value, this amount is not very significant, but it serves to show the ratio which exists between the amounts in the ground and drain waters or the extent to which the soil retains the potash, if we may put it that way.

§ 93. In regard to the sodic salts we find a difference between the sulfates and chlorids. Adopting the average percentage of sodic sulfate found in the total solids of well A in 1898, which is probably a little too high to be accurate but will represent the general facts with sufficient accuracy, we find in an acre-foot of the ground water 868 pounds of sodic sulfate, and in a like quantity of drain water 168 pounds, or one-fifth as much. In Bulletin No. 72 I called attention to the fact that the salts in solution fell as the water plane fell, the salts seeming to remain in the soil. I also called attention to the fact that the upper portions of the ground water were richer in total solids than the lower and at the same time contained higher percentages of sodic sulfate. I find in the drain water further proof of what I then observed by taking samples directly from the soil. We see that sodic sulfate does not pass readily into the drain waters. Not only the absolute amount falls, but its relative amount, showing that the soil particles retain it as there suggested.

§ 94. The sodic chlorid deports itself in the same manner. Again, using well A as an example, we have in an acre-foot of its water 925 pounds of sodic chlorid, or common salt, and 240 pounds in an acre-foot of drain water. I have compared other well waters and find this to be the rule. The difference is not necessarily the same but it is always in the same direction. The only time that the percentage of sodic chlorid in the total solids of the ground waters approaches that of those of the drain waters, is when the water plane has fallen quite low, in other words, when it has approached the level of the drain. These statements do not seem to be in perfect harmony with the theory of absorption of salts by different soils, and the fact that, as a rule, there is an excess of bases in the residues left by these waters, rather than acids, as would be required by the theories set forth in our text books, points to the prevalence of conditions entirely different from those under which the classical experiments, upon which our theories are based, were made.

§ 95. Only two of these drain waters were submitted to sanitary analysis, with the following results:

TABLE XLIII.—SANITARY ANALYSES OF DRAIN WATERS

1. Drain water, Mrs. Calloway's ranch, July 23, 1900.
2. Drain east of beet plot, July 23, 1900.

	Total Solids	Chlorin	Nitrates		Nitrites		Ammonia		Albuminoidal Ammonia		Oxygen Consumed
			Nitrogen	Nitric Acid	Nitrogen	Nitrous Acid	Nitrogen	Ammonia	Nitrogen	Ammonia	
1	880 5	40.7	0.240	1.0770	0.1400	0.4690	0.0410	0.0496	0.1000	0.1210	1.3650
2	1047.1	44.8	0.480	2.1540	1.3000	4.3550	0.0720	0.0871	0.1900	0.2299	2.0500

§ 96. I regret that these samples were not taken at the same time that the samples of irrigation water were taken, but they were not, and these will have to serve our purpose in such measure as they may.

§ 97. It will be seen by referring to the table of analyses of irrigation waters that the well waters taken August 31, 1899, before irrigation, were richer in nitric acid than these drain waters, as were also those taken after irrigation; but the drain waters are very much richer in nitrous acid. The ammonia, both saline and albuminoidal, is less in the drain water than in the irrigation and ground waters. The nitric acid removed per acre-foot by the richer of the two drainage waters is but 5.748 pounds. In the course of a year the amount of nitric acid in pounds avoirdupois transported by such waters, in the form of nitrates, is a comparatively large number, but when we attempt to estimate the area from which this is collected and think of the scale on which na-

ture operates, the amount is trifling. An example will show how thoroughly justified is this statement. If our soil contained 0.1 per cent. of nitrogen and we take two acre-feet of it, it will contain in round numbers 7,000 pounds of nitrogen. It would take 1,227 acre-feet of drain water to contain this amount, taking all forms of nitrogen existing in the water. The drain water does not, unfortunately, represent the water draining from any given acre of soil, but that draining from many acres. It is understood that the value of such examples is purely illustrative.

THE RETURN WATERS.

§ 98. We have considered the Poudre water and seen that it suffers little or no change in character so long as it remains in its mountain course, but that its character changes rapidly as it enters the plains. We have seen that in flowing through the ditches for use in direct irrigation it also changes rapidly. (See table XII—analysis of ditch water as used for irrigation). We have studied the effects of storage upon the amount and character of the salts held in solution. (See analysis of waters of Terry lake, Long pond, Warren's and Windsor lakes). We have further endeavored to present the manner and extent that its composition is changed by flowing over the soil as off-flow water; by entering the soil as ground water; by passing through and flowing out of it as drain water.

§ 99. If possessed with the desire to do so, anyone could make suggestions which, had they been feasible at the time, or perhaps even been seen as they can now be seen, would, if followed out, add greatly to the value of this work. From the very beginning I desired to make a study of the changes taking place upon the application of water for irrigation purposes in a different manner, but it was not feasible and I have done the best that I could. While I think the results of my experiments in this regard exaggerate some of the relations of the individual results to one another, I am not prepared to regret the fact, for I believe that the exaggeration serves a good purpose by emphasizing; for instance, the profound manner in which the laws of diffusion are modified within the soil, and the tenacity with which the soil particles retain the molecules of different salts, without in any appreciable way destroying their value, as a presentation of the typical reactions which take place. I think that it is true everywhere under our conditions that calcic sulfate is permitted to pass with comparatively more freedom than sodic sulfate or chlorid. I do not know whether this is due to the presence of this salt in quantities approaching the point of saturation of the soil and water, or not. With whatever weaknesses and insufficiencies our experiments may be beset, we have placed them upon record and will

examine what the results of the bigger practice, i. e., the irrigation of the whole valley may show.

§ 100. I have stated that seepage or return waters begin to enter the river almost immediately upon its leaving the mountains, and have cited the increase in the total solids in the river water between a point above the North Fork and the water works, in support of it. The amount of such water increases as we go down the river.

§ 101. We can present the matter thus: The water of the Poudre is taken from the river, used for irrigation, and after a time returns. The return waters have passed through or flowed over the soil. The amount returning to the river as waste water, is so small that I would not take note of it, even if I had sufficient data to justify me in attempting to do so. But I have not such data. Much of the water appearing in the lower part of the river has doubtlessly been used several times, but I doubt whether its composition is, on this account, any more or less indicative of the effects of the irrigation waters upon the soil, or of changes which take place within the soil, than water which has not been used repeatedly. I am inclined to think that in such cases the composition of the return waters is dependent almost wholly upon the character of the soil from which it last issued. This question is of great importance in interpreting the results of the analysis of return waters. The river bed may be bordered by a margin of low land, as it frequently is, the water draining from the higher land having to pass through this, either in small streams or by the slower method of percolation. In either event there is opportunity for a material modification of the composition of the water. Still, as has already been said, we have in the return waters the result of all the changes, and a measure of the effects produced by irrigating, not a field, but a whole section of country. Our measure is essentially the drain water of all this larger section, and in this case drain water means water that has passed through, not run over, the soil as rain water or as waste water from ditches.

§ 102. In order to save space and bring the analyses of return waters together, I will anticipate a little and introduce the analysis of the Platte river water below the mouth of the Poudre, it being return water, but I shall give those of the Poudre the first place, not only in order, but in importance.

TABLE XLIV.—ANALYSIS OF POUDRE RIVER WATER, SAMPLE TAKEN TWO MILES ABOVE GREELEY, AUGUST 11, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.904	1.035
Sulfuric Acid	48.009	54.970
Carbonic Acid	5.171	5.920
Chlorin	2.419	2 770
Sodic Oxid	12.742	14.590
Potassic Oxid	0.394	0 451
Calcic Oxid	16.540	18.938
Magnesic Oxid	10 646	12.190
Ferric and Al. Oxids	0.069	0.079
Manganic Oxid	Trace	Trace
Ignition	3.660	4 191
Sum	100.554	115.134
Oxygen Eq. to Cl.	0.545	0.634
Total	100.009	114.500

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	40.186	46.013
Magnesic Sulfate	31.796	36.406
Potassic Sulfate	0.628	0.719
Sodic Sulfate	5.292	6.059
Sodic Chlorid	3.987	4.565
Sodic Carbonate	12.469	14.277
Sodic Silicate	1.833	2.099
Ferric and Al. Oxids	0 069	0.079
Manganic Oxid	Trace	Trace
Ignition	3.660	4.191
Sum	99 920	114.408
Excess Sodic Oxid	0.084	0.096
Total	100.004	114.504

Total solids 114.5 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	1,017.140
Chlorin	36.630
Nitrogen as Nitrates	0.400
Nitrogen as Nitrites	0 022

	Parts Per Million.
Saline Ammonia	0 060
Albuminoidal Ammonia	0.160
Oxygen consumed	1.160

TABLE XLV.—ANALYSIS OF POUDRE RIVER WATER, SAMPLE TAKEN THREE MILES EAST OF GREELEY, AUGUST 10, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.336	0.951
Sulfuric Acid	42.660	30.374
Carbonic Acid	7.144	5.087
Chlorin	3.013	2.145
Sodic Oxid	12.819	9.117
Potassic Oxid	0.523	0.372
Calcic Oxid	19.785	14.087
Magnesic Oxid	7.854	5.592
Ferric and Al. Oxids	0.055	0.039
Manganic Oxid	0.110	0.078
Ignition	5.433	3 868
Sum	100.731	71.710
Oxygen Eq. to Cl.	0.679	0.483
Total	100.052	71.227

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	48.068	34.124
Magnesic Sulfate	21.621	15.394
Magnesic Chlorid	1.431	1.019
Potassic Chlorid	0 827	0 589
Sodic Chlorid	2.566	1 827
Sodic Carbonate	17.227	12.266
Sodic Silicate	2.710	1.930
Ferric and Al. Oxids	0.055	0.039
Manganic Oxid	0.110	0.078
Ignition	5.433	3.868
Sum	100.048	71.134
Excess	None	None
Total	100.048	71.134

Total solids, 71.2 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	1,635.710
Chlorin	45.550
Nitrogen as Nitrates	0.300
Nitrogen as Nitrites	0.015

	Parts Per Million.
Saline Ammonia	0.120
Albuminoidal Ammonia	0.180
Oxygen consumed	2.127

TABLE XLVI.—ANALYSIS OF PLATTE RIVER WATER, SAMPLE TAKEN ONE MILE SOUTH AND FOUR EAST OF GREELEY, AUGUST 11, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	1.214	0.891
Sulfuric Acid	44.416	32.601
Carbonic Acid	6.205	4.554
Chlorin	3.653	2.681
Sodic Oxid	15.617	11.463
Potassic Oxid	0.483	0.355
Calcic Oxid	17.966	13.117
Magnesic Oxid	7.535	5.530
Ferric and Al. Oxids	0.257	0.189
Manganic Oxid	0.257	0.189
Ignition	3.266	2.397
Sum	100.869	73.967
Oxygen Eq. to Cl.	0.823	0.604
Total	100.046	73.372

Combined	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	43.651	32.040
Magnesic Sulfate	22.504	16.518
Potassic Sulfate	0.892	0.655
Sodic Sulfate	5.959	4.374
Sodic Chlorid	6.028	4.425
Sodic Carbonate	14.962	10.982
Sodic Silicate	2.087	1.532
Ferric and Al. Oxids	0.257	0.189
Manganic Oxid	0.257	0.189
Ignition	3.266	2.397
Sum	99.863	73.301
Excess Silicic Acid	0.124	0.091
Total	99.987	73.392

Total solids, 73.4 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	1,048.570
Chlorin	42.590
Nitrogen as Nitrates	0.400
Nitrogen as Nitrites	0.015

	Parts Per Million.
Saline Ammonia	0.020
Albuminoidal Ammonia	0.150
Oxygen consumed	0.994

§ 103. The samples of Poudre water were taken at points at least seven miles apart as the river flows. The water on this date was not only representative of return water, but was wholly such as had come into the river within the last few miles above these points. The water taken at the lower point had, for the greater part, returned within the last seven miles. This fact may account for the differences presented by the analyses. There is no reason for any one to stumble over, or raise any question about, the manner of combining these salts, for the variations which can be shown in this way have no weight in the larger features presented by these results.

§ 104. The three principal salts in these waters are, in the order of their relative quantities, calcic sulfate, magnesic sulfate and sodic carbonate. The sulfate of soda present in such notable quantities in the ground waters, and still more so in nearly all of the efflorescences, is very subordinate or absent. The potassic oxid is present in a slightly higher percentage than the average found for our ground waters, but the total solids is very much less.

§ 105. The sanitary analyses show that in total nitrogen the return waters are not so unlike the ground waters as one would expect, as they resemble those taken before irrigation quite closely. The only exception being the Arkansas river water, taken at Rockyford, in which we found large quantities of both nitrates and nitrites. I know much less about the conditions obtaining in re-

gard to this sample than in the other cases, and it is not feasible for me to gather the facts in this case with the completeness and accuracy that would permit me to make any explanatory statements, therefore I content myself with recording the results of the analysis which is given later.

§ 106. Fortunately the Poudre river was gauged in 1902, a few days before my samples were taken, and we have very excellent data enabling us to calculate the results indicated by our analyses, with the assurance that they are correct within narrow limits. On July 27, the flow at the pump house above Greeley was 24 second-feet, at the mouth of the river it was 29 second-feet. We will use the latter figure in calculating the total work done by the Poudre river as an irrigation stream. This flow delivers nearly 2.4 acre-feet per hour, or 57.6 acre-feet per day. At the pump house the flow amounted almost to 48 acre-feet per day. As the supply of water during the season of 1902 was very short, we may consider the following figures as representing the minimum effect of the stream.

§ 107. With a flow of 57.6 acre-feet daily, it carries a total of 79.75 tons of salts into the Platte river. A like quantity of water, as it flows through the canyon of the Poudre, would contain only 3.25 tons, or a gain of 76.5 tons, but the flow at the mouth of the river is not the same as in the canyon, it being much greater. The following figures will show the total salts carried through the canyon in solution, and will also give an idea of the daily consumption of water taking place between the canyon and the mouth of the river. The weight of the salts carried through the canyon of the Poudre on this date was 32.5 tons. The amount delivered to the Platte was 79.75 tons, a difference of 47.25 tons. This naked statement of end results does not give a fair idea of the work accomplished. The water had all been taken out of the Poudre, together with the return water, and at a point six miles above its mouth, just below the Camp ditch, it was entirely dry. Yet, there was a discharge of 29 second-feet at its mouth carrying 80 (79.75) tons of salts, all of which must have come into the river within the intervening six miles.

§ 108. To show still further how inadequate this way of presenting the matter is, I will take the analysis of the sample from above Greeley, where the flow was 24 second-feet and the total solids 114.5 grains per imperial gallon. There were accordingly 100.8 tons of salts being carried past this point daily, but the gaging shows that there was an increase of 21 second-feet between this point and the Camp ditch, which of course increased the quantity of salts being carried by the river. The Camp ditch took all of the water in the river at this point and consequently took not only the 101 tons of salts, but much more, including the

sewage of the town of Greeley. The water returning within the next six miles came from land irrigated with this water and carried, in round numbers, 80 tons of salts. Our method shows the net results effected, but the work done by the irrigation waters is actually much greater than the figures indicate.

§ 109. The salts removed stand as follows in the order of their relative quantities; calcic sulfate, magnesic sulfate, sodic carbonate and sodic sulfate. In the case of the Arkansas river water, the sodic sulfate stands next to the calcic sulfate. The samples of ground water from the Arkansas valley which I have examined, have been very rich in total solids with much sodic sulfate. In one there was over 57 per cent of this salt and in another almost 30 per cent.

§ 110. It is true, the area in the Poudre valley under irrigation, the seepage water from which finds its way into the Poudre, is large. In 1894 it was 176,848 acres. It is now much greater, but the amount of salts carried out of the valley under the conditions of 1902 is also large. Assuming the flow of 29.1 feet of water, as found by us, to continue for 270 days—the results will be too low, for the flow is at least six second-feet below the average—we will have removed from the valley 21,532.5 tons of salts, over one-third of which is calcic sulfate, one-fourth magnesic sulfate and a little less than one-eighth sodic carbonate.

§ 111. I am not certain that the Arkansas water is comparable as a return water to these samples of Poudre water. If it is, the ratio would be materially changed and we would have 2-5 for the calcic sulfate, 1-5 for the sodic sulfate, almost 1-5 for the magnesic sulfate and very much less sodic carbonate. The analysis of this water shows a very considerable excess of bases. I have already called attention to the fact that this sometimes occurs and that I am unable to satisfactorily account for it. The alkalies and some other determinations were repeated in this analysis with excellently agreeing results. We therefore leave the excess unexplained.

§ 112. The analysis of the Platte river water gives results in agreement with those of the Poudre water and there is nothing to be gained by further discussion of this. The flow of the Platte at this point is very much larger than that of the Poudre and the amount of salts carried will be almost exactly proportional to their respective flows. All that has been said concerning the Poudre could be repeated concerning the Platte. Its water is made to repeatedly serve the purposes of irrigation. Their waters receive the sewage of several towns, the Platte proportionately more than the Poudre. The general character of the land irrigated is similar and so are the general features of the results produced.

§ 113. Too much emphasis should not be laid upon the similarities between the composition of the drain waters analyzed

and these return waters, for, as already clearly stated, the return water taken near the mouth of the Poudre must have come in within the last six miles of its course. Still it seems that the drain waters and these return waters are representative of the end results produced by water applied to our soils, and passing through it to a depth of say four and one-half feet, and then finding a free channel of escape. These similarities are clearly shown by the analyses, the average percentages of which are as follows: Calcic sulfate in return water, 44.2; in drain water, 43.9; magnesic sulsulfate in return water, 25.2; drain water, 22.4; sodic sulfate, return water, 3.3; drain water, 4.3 per cent. The reason for the omission of the Arkansas river water at Rockyford from these averages is evident from what has been previously said.

THE WATERS OF SOME OTHER STREAMS.

§ 114. The streams of this section of Colorado including the Laramie, Poudre, Big Thompson, St. Vrain, Boulder, Clear Creek, South Platte and Arkansas, have collecting grounds of essentially the same character. Some of them, it is true, receive drainage from large parks, but these are surrounded by mountains of the same character as those forming the collecting areas of the other streams. The South Platte, for instance, receives drainage from South Park, but this water, springs excepted, some of which in this case are very rich in mineral matter and others are brines which at one time were used as a source of salt, comes from the mountains. Some of the tributaries of the South Platte carry as pure water as is to be found within the state.

§ 115. The analyses of these waters will be given without comment, except such as is necessary to a reasonable understanding of the samples, some of which, like the water served to the town of Fort Collins, fail to represent the true character of the water, but represent it after the stream has become a plains stream and has already received enough seepage to perceptibly modify its composition. This applies to all the following samples with the exception of the Boulder and Clear Creek samples. The sample of Platte river water was taken from a tap in the City of Denver, but inquiry of the Denver Union Water Company elicited the fact that the water obtained was not pure Platte river water, but was a mixture of this with water from some other sources of supply. For analyses of Poudre river water see table II.

TABLE XLVII.—ANALYSIS OF BIG THOMPSON WATER, SAMPLE TAKEN THREE MILES WEST OF LOVELAND, AUGUST 20, 1902.

Analytical Results	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	3.890	0.447
Sulfuric Acid	43.331	4.983
Carbonic Acid	6.768	0.778
Chlorin	0.565	0.065
Sodic Oxid	4.771	0.549
Potassic Oxid	0.430	0.049
Calcic Oxid	24.833	2.856
Magnesic Oxid	9.790	1.126
Ferric and Al. Oxids	0.169	0.019
Manganic Oxid	0.019	0.002
Ignition	[5.561]	0.640
Sum	100.127	11.514
Oxygen Eq. to Cl.	0.127	0.015
Total	100.000	11.499

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	60.335	6.939
Magnesic Sulfate	11.775	1.354
Magnesic Carbonate	11.789	1.356
Magnesic Chlorid	0.482	0.055
Potassic Chlorid	0.433	0.050
Potassic Silicate	0.257	0.029
Sodic Carbonate	1.492	0.172
Sodic Silicate	7.688	0.884
Ferric and Al. Oxids	0.169	0.019
Manganic Oxid	0.019	0.002
Ignition	[5.561]	0.640
Sum	100.000	11.500
Excess	None	None
Total	100.000	11.500

Total solids 11.5 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	164.290
Chlorin	2.970
Nitrogen as Nitrates	0.300
Nitrogen as Nitrites	None

	Parts Per Million.
Saline Ammonia	0.030
Albuminoidal Ammonia	0.120
Oxygen consumed	1.625

TABLE XLVIII.—ANALYSIS OF ST. VRAIN WATER, TAKEN THREE MILES WEST OF LONGMONT, AUGUST 19, 1902.

Analytical Results	*Per Cent*	*Grs. Imp. Gal.*
Silicic Acid	3.074	0.483
Sulfuric Acid	41.873	6.574
Carbonic Acid	7.945	1.247
Chlorin	0.957	0.150
Sodic Oxid	10.117	1.588
Potassic Oxid	0.533	0.084
Calcic Oxid	20.601	3.234
Strontic Oxid	0.172	0.027
Magnesic Oxid	9.892	1.553
Ferric and Al. Oxids	0.199	0.031
Manganic Oxid	0.054	0.008
Ignition	5.179	0.813
Sum	100.596	15.792
Oxygen Eq. to Cl.	0.215	0.034
Total	100.381	15.758

Combined.	*Per Cent*	*Grs. Imp. Gal.*
Calcic Sulfate	50.053	7.858
Strontic Sulfate	0.305	0.048
Magnesic Sulfate	18.482	2.902
Magnesic Carbonate	7.729	1.223
Potassic Chlorid	0.844	0.133
Sodic Chlorid	0.915	0.144
Sodic Carbonate	9.438	1.482
Sodic Silicate	6.234	0.979
Ferric and Al. Oxids	0.199	0.031
Manganic Oxid	0.054	0.008
Ignition	5.179	0.813
Sum	99.432	15.591
Excess Sodic Oxid	0.948	0.149
Total	100.380	15.740

Total solids, 15.7 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Totall Solids	224.290
Chlorin	4.950
Nitrogen as Nitrates	0.100
Nitrogen as Nitrites	None

	Parts Per Million.
Saline Ammonia	0.300
Albuminoidal Ammonia	0.140
Oxygen consumed	2.026

TABLE XLIX.—ANALYSIS OF BOULDER CREEK WATER, TAKEN FROM TAP IN BOULDER, AUG. 27, 1902. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	21.985	0.6156	Calcic Sulfate	14.124	0.3955
Sulfuric Acid	8.305	0.2325	Calcic Carbonate	31.317	0.8769
Carbonic Acid	17.037	0.4770	Strontic Carbonate	0.235	0.0066
Chlorin	7.425	0.2079	Magnesic Carbonate	6.143	0.1720
Sodic Oxid	6.870	0.1924	Magnesic Chlorid	4.305	0.1205
Potassic Oxid	2.720	0.0762	Potassic Chlorid	4.304	0.1205
Lithic Oxid	Trace	Trace	Sodic Chlorid	3.586	0.1004
Calcic Oxid	23.373	0.6544	Sodic Silicate	9.818	0.2749
Strontic Oxid	0.165	0.0046	Lithic Oxid	Trace	Trace
Magnesic Oxid	4.760	0.1313	Ferric and Al. Oxids	1.098	0.0307
Ferric and Al. Oxids	1.098	0.0307	Manganous Oxid	0.341	0.0095
Manganous Oxid	0.340	0.0095	Zincic Oxid	Trace	Trace
Zincic Oxid	Trace	Trace	Ignition	[7.607]	0.2130
Ignition	[7.607]	0.2130	Sum	82.878	2.3205
Sum	101.676	2.8451	Excess Silicic Acid	17.144	0.4789
Oxygen Eq. to Cl.	1.676	0.0469	Total	100.022	2.7994
Total	100.000	2.7982			

Total solids, 2.8 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.		*Parts Per Million.*
Total Solids	40.000	Saline Ammonia	Trace
Chlorin	2.970	Albuminoidal Ammonia	0.050
Nitrogen as Nitrates	0.100	Oxygen consumed	1.170
Nitrogen as Nitrites	None		

* Attention is called to the similarity of this analysis to those of the Poudre water, pages 13, 14 and 15.

TABLE L.—ANALYSIS OF WATER DRAWN FROM TAP IN OFFICE OF DENVER FIRE CLAY CO., DENVER, AUG. 26, 1902.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*	*Combined.*	*Per Cent.*	*Grs. Imp. Gal.*
Silcic Acid	2.573	0.427	Calcic Sulfate	43.853	7.280
Sulfuric Acid	25.785	4.280	Calcic Carbonate	9.943	1.651
Carbonic Acid	14.110	2.342	Magnesic Carbonate	12.587	2.089
Chlorin	7.508	1.240	Potassic Carbonate	1.849	0.307
Sodic Oxid	13.447	2.232	Sodic Chlorid	12.390	2.057
Potassic Oxid	1.261	0.209	Sodic Carbonate	6.236	1.035
Calcic Oxid	23.640	3.924	Sodic Silicate	5.218	0.866
Magnesic Oxid	6.022	1.000	Ferric and Al. Oxids	0.071	0.012
Ferric and Al. Oxids	0.071	0.012	Manganic Oxid	0.178	0.030
Manganic Oxid	0.178	0.030	Ignition	7.097	1.178
Ignition	7.097	1.178	Sum	99.422	16.505
Sum	101.692	16.874	Excess Sodic Oxid	0.576	0.095
Oxygen Eq. to Cl.	1.692	0.281	Total	99.998	16.600
Total	100.000	16.593			

Total solids 16.6 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.		*Parts Per Million.*
Total Solids	237.142	Saline Ammonia	0.100
Chlorin	21.780	Albuminoidal Ammonia	0.180
Nitrogen as Nitrates	0.500	Oxygen consumed	1.453
Nitrogen as Nitrites	0.540		

TABLE LI.—ANALYSIS OF CLEAR CREEK WATER, TAKEN FROM WELCH DITCH ONE MILE W. OF GOLDEN, AUG. 27, 1902.

Analytical Results.	*Per Cent*	*Grs. Imp. Gal.*
Silicic Acid	17.953	1.3644
Sulfuric Acid	24.844	1.8881
Carbonic Acid	6.870	0.5221
Chlorin	2.479	0.1884
Sodic Oxid	7.073	0.5375
Potassic Oxid	3.506	0.2665
Lithic Oxid	Trace	Trace
Calcic Oxid	21.041	1.5991
Strontic Oxid	Trace	Trace
Magnesic Oxid	4.011	0.3048
Zincic Oxid	0.207	0.0127
Aluminic Oxid	2.477	0.1883
Ferric Oxid	1.916	0.1456
Manganic Oxid	0.691	0.0525
Cupric Oxid	Trace	Trace
Plumbic Oxid	None	None
Ignition	7.491	0.5693
Sum	100.559	7.6423
Oxygen Eq. to Cl.	0.559	0.0425
Total	100.000	7.5998

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	42.252	3.2111
Calcic Carbonate	6.483	0.4927
Magnesic Carbonate	7.707	0.5856
Magnesic Chlorid	0.764	0.0581
Potassic Chlorid	4.017	0.3053
Potassic Silicate	1.578	0.1197
Sodic Silicate	13.952	1.0604
Lithic Oxid	Trace	Trace
Aluminic Oxid	2.477	0.1883
Ferric Oxid	1.916	0.1450
Zincic Oxid	0.207	0.0157
Cupric Oxid	Trace	Trace
Plumbic Oxid	None	None
Manganic Oxid	0.691	0.0525
Ignition	7.491	0.5693
Sum	89.535	6.8036
Excess Silicic Acid	10.464	0.7953
Total	99.999	7.5989

Total solids, 7.6 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	108.571
Chlorin	2.970
Nitrogen as Nitrates	0.200
Nitrogen as Nitrites	0.013

	Parts Per Million.
Saline Ammonia	0.040
Albuminoidal Ammonia	0.140
Oxygen consumed	2.360

TABLE LII.—ANALYSIS OF ARKANSAS RIVER WATER, TAKEN AT CANON CITY, FEBRUARY 2, 1898. *

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	7.840	0.847
Sulfuric Acid	11.676	1.261
Carbonic Acid	26.383	2.849
Chlorin	3.699	0.399
Sodic Oxid	12.364	1.335
Potassic Oxid	0.689	0.074
Calcic Oxid	27.149	2.932
Magnesic Oxid	8.193	0.885
Ferric and Al. Oxids	0.215	0.023
Manganic Oxid	0.098	0.011
Ignition	2.528	0.273
Sum	100.000	10.889
Oxygen Eq. to Cl.	0.834	0.090
Total	100.000	10.799

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	18.863	2.037
Calcic Carbonate	34.565	3.733
Magnesic Carbonate	17.185	1.856
Potassic Sulfate	1.275	0.138
Sodic Chlorid	6.102	0.659
Sodic Carbonate	5.305	0.573
Sodic Silicate	11.860	1.280
Ferric and Al. Oxids	0.215	0.023
Manganic Oxid	0.098	0.011
Ignition	2.528	0.273
Sum	97.996	10.283
Excess Silicic Acid	2.003	0.216
Total	99·999	10.799

Total solids, 10.8 grains per imperial gallon.
No sanitary analysis made of this sample.

TABLE LIII.—ANALYSIS OF ARKANSAS RIVER WATER, TAKEN AT BRIDGE NEAR ROCKYFORD, APRIL 24, 1903.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.428	0.669
Sulfuric Acid	48.299	75.540
Carbonic Acid	1.858	2.905
Chlorin	4.667	7.299
Sodic Oxid	18.662	29.187
Potassic Oxid	0.326	0.510
Calcic Oxid	17.090	26.729
Magnesic Oxid	5.993	9.373
Ignition	4.346	6.797
Sum	101.669	159.010
Oxygen Eq. to Cl.	1.051	1.644
Total	100.618	157.366

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	41.523	64.942
Magnesic Sulfate	17.899	27.994
Potassic Sulfate	0.602	0.942
Sodic Sulfate	20.747	32.449
Sodic Chlorid	7.701	12.044
Sodic Carbonate	4.480	7.007
Sodic Silicate	0.868	1.358
Ignition	4.346	6.797
Sum	98.166	153.533
Excess Sodic Oxid	2.450	3.832
Total	100.616	157.365

Total solids 156.4 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	2,234.290
Chlorin	103.971
Nitrogen as Nitrates	1.500
Nitrogen as Nitrites	0.040

	Parts Per Million.
Saline Ammonia	0.065
Albuminoidal Ammonia	0.140
Oxygen consumed	2.000

TABLE LIV.—ANALYSIS OF WATER FROM QUEEN RESERVOIR, SAMPLE TAKEN JANUARY 23, 1903.

Analytical Results.	*Per Cent.*	*Grs. Imp. Gal.*
Silicic Acid	0.273	0.197
Sulfuric Acid	48.973	35.407
Carbonic Acid	3.370	2.437
Chlorin	3.810	2.755
Sodic Oxid	17.066	12.339
Potassic Oxid	0.493	0.356
Calcic Oxid	15.095	10.914
Magnesic Oxid	7.937	5.738
Ferric and Al. Oxids	0.075	0.054
Manganic Oxid	0.075	0.054
Ignition	[3.692]	2.669
Sum	100.859	72.920
Oxygen Eq. to Cl.	0.859	0.621
Total	100.000	72·299

Combined.	*Per Cent.*	*Grs. Imp. Gal.*
Calcic Sulfate	36.765	26.581
Magnesic Sulfate	23.705	17.139
Potassic Sulfate	0.911	0.659
Sodic Sulfate	19.900	14.388
Sodic Chlorid	6.287	4.546
Sodic Carbonate	8.125	5.874
Sodic Silicate	0.554	0.401
Ferric and Al. Oxids	0.075	0.054
Manganic Oxid	0.075	0.054
Ignition	[3.692]	2.669
Sum	100.089	72.365
Excess	None	None
Total	100.089	72.365

Total solids 72.3 grains per imperial gallon.

SANITARY ANALYSIS.

	Parts Per Million.
Total Solids	1,032.850
Chlorin	47.529
Nitrogen as Nitrates	Trace
Nitrogen as Nitrites	0.010

	Parts Per Million.
Saline Ammonia	0.060
Albuminoidal Ammonia	0.620
Oxygen consumed	6.415

§ 116. In glancing at these analyses, a few things will be noticed. First, that the waters of our mountain streams are of excellent quality and carry a small amount of salts in solution; second, that the amount of salts held in solution is materially increased almost immediately upon their entering the plains, particularly after they emerge from the foothills; third, that the waters of the mountain streams contain calcic sulfate—almost as their only sulfate—after this, carbonates and silicates; fourth, that the carbonates and silicates are rapidly exchanged for magnesic and sodic sulfates upon entering the plains (compare tables LII. and LIII.) While these samples are not strictly comparable as samples of Arkansas river water, because of the length of time elapsing between the dates on which the samples were taken, they illustrate well the differences between the mountain and plains waters. A still better illustration will be found by comparing table III, an analysis of Poudre water, with table XI, an analysis of Windsor lake water, or with table XLIV, an analysis of Poudre river water, taken above Greeley. The influence of the plains is already discernible in the composition of the water drawn from the tap in the chemical laboratory, also in samples of the Big Thompson and St. Vrain, taken a few miles west of the towns of Loveland and Longmont respectively.

§ 117. The sample of the Arkansas river water, taken near Rockyford, probably represents seepage water, but the extremely large amounts of nitrates and nitrites met with in the sanitary analysis suggest sewage. I am satisfied, however, that such is not the case, no sewage entering nearer than Pueblo, which is 70 miles above, and this is taken out by the ditches. The person who took this sample reported the water as very clear and the ditches above as taking all of the river water. We have in this sample, I believe, as good a one of return waters for the river at this point as could possibly have been obtained. It differs somewhat from the Poudre return waters in containing a good percentage of sodic sulfate. This salt is present, however, in the ground waters of this district in large quantities.

§ 118. The analysis of the water of the Queen Reservoir represents flood water which had been stored 22 months and was obtained through the kindness of Mr. W. M. Wiley. The salts held in solution differ in amount and slightly in their relative quantities, but it otherwise agrees with the seepage water taken at the bridge near Rockyford. This may be due to the return waters entering the river during flood time, but this would seem to indicate a very great in-flow of return waters at such a period, and it would seem that a portion, at least, of these salts must find their way into the water, either in the ditch or reservoir, during the period of storage. The Arkansas river in the month of February,

a month of low water, carried only 10.8 grains. This flood water, after storage for twenty-two months, carried 72 grains. Our data is not sufficiently full to enable us to go further with this discussion.

§ 119. The work done by the irrigating waters of the Arkansas valley is evidently similar to that done by them in the Poudre valley, and so far as the rate at which the salts are carried out of the soil is indicated by the contents of total solids per gallon, it is very nearly the same, differing principally in carrying a fairly large percentage of sodic sulfate, while the Poudre return water carries relatively but little or none of this salt.

THE SUSPENDED MATTER CARRIED IN TIMES OF HIGH WATER.

§ 120. This will vary both in amount and character, according to the conditions prevailing within the drainage area of the streams carrying it. The Rio Grande, in New Mexico, would scarcely be expected to carry the same character of suspended matter, especially after a torrential rain somewhere within its plains section, as at Del Norte, Colorado, after a similar rain in the mountain districts to the west of it.

§ 121. The amount of sediment, as I have found it, has been a great disappointment to me, it being very small in amount compared with my preconceived notions, and of a somewhat different quality.

§ 122. On May 22, 1902, we had an excellent opportunity of obtaining a sample of Poudre flood water, caused by a heavy rainfall within the foothills, whereby the river was swollen to such an extent that it passed beyond its bounds. It carried on this date 12,000 second-feet, or about ten times its usual volume at this season of the year. This water was very thick with mud and debris, such as the unusual volume of water would tear loose along its course. I had a large sample, 102 pounds, of this water collected from the middle of the stream. The bucket with which the water was dipped was allowed to sink as far as it would in such a current. The whole sample was allowed to settle for several days, on account of the suspended clay, and then filtered. The suspended matter amounted to 0.213 per cent, or 2,130 parts per million. The analysis of the sediment gave the following results:

TABLE LV.—ANALYSIS OF SUSPENDED MATTER CARRIED IN FLOOD WATER OF POUDRE RIVER, MAY 22, 1902.

	PER CENT.
Silicic Acid	61.482
Sulfuric Acid	None
Carbonic Acid	0.350
Chlorin	Trace
Phosphoric Acid	None
Potassic Oxid	2.663
Sodic Oxid	1.519
Calcic Oxid	2.575
Mangesic Oxid	1.948
Ferric Oxid	6.826
Aluminic Oxid	7.866
Manganic Oxid	0.461
Moisture	8.040
Ignition	6.485
Total	100.213

Nitrogen 0.306 per cent.

§ 123. Our people do not have opportunity to apply such water in irrigating, and there is but little object in calculating what the value of an acre foot of it would be, still some may be curious to see the figures. The total suspended matter per acre foot would be 5,799 pounds. The total potash (K_2O) would be 154 pounds; the total nitrogen, 17 pounds, and the total organic matter 377 pounds.

§ 124. While the suspended matter, in this case, came from the foothills, it is not so different in its composition from that usually carried by this stream as would be anticipated.

§ 125. A sample of Arthur ditch water was taken July 5, 1900, when the river was high, and the water much more turbid than usual. The percentage of suspended matter was found to be only 0.0016, 16 pounds per million, or 44 pounds per acre foot. The sample taken was sufficiently large, over 100 pounds, to give entirely trustworthy results. The analysis was made by fluxing with calcic carbonate, therefore the lime and magnesia are included in the undetermined. The analysis gave the following results:

TABLE LVI.--ANALYSIS OF SUSPENDED MATTER IN ARTHUR DITCH WATER, SAMPLE TAKEN JULY 5, 1900.

	PER CENT.
Silicic Acid	58.858
Potassic Oxid	2.818
Sodic Oxid	1.998
Ferric Oxid	6.985
Aluminic Oxid	11.505
Ignition	9.722
Undetermined	8.084
Total	100.000

§ 126. The potassic and sodic oxids in these two sediments are nearly the same; the silicic acid, iron and aluminic oxids are as nearly so as we could expect to find in samples taken on different days, with like conditions prevailing in the river, instead of samples taken under very unlike conditions. In this case, these samples show that there is very little difference in the suspended matter brought from the mountains by the flood water, produced by the melting snow, and that carried into the river by torrential rains within the foothills. This remark applies to the inorganic constituents only, and would not be strictly applicable to heavy rains falling within the sections where the red clays of the jura-triassic abound. The ignited suspended matter of May 22, shows an abundance of red clay.

§ 127. The Queen Reservoir was filled with flood water from the Arkansas river. As the reservoirs, of which this is only one, are filled in this manner for the most part, I obtained through the kindness of Mr. W. M. Wiley a sample of the silt deposited in this reservoir. This matter had evidently been some time in accumulating. It is difficult to see how this may have been silt carried by the flood waters of the Arkansas, and yet the judgment of Mr. Wiley and his assistants ought to be thoroughly reliable in this matter. When passed through a fifty mesh sieve 15 per cent of it remained upon the sieve. Before ignition, bits of coal were easily recognizable among the large fragments of roots, stems, etc. It is possible that these bits of coal had been swept along by the flood waters from Canon City or Pueblo. After ignition the mineral and rock particles recognizable were mica, quartz, felspar and grains of a vesicular igneous rock, probably andesite. The latter was abundant. There were also fragments of shells and pear-shaped bodies, being quite sharp at one end. Some of these were spirally marked, others apparently not. These bodies dissolved in hydrochloric acid with effervescence, and were probably seed or spore cases of chara.

§ 128. I am not familiar enough with the country to suggest any source for the particles of igneous rock, but if I have made no mistake they have probably been transported a long way. The part that passed through the sieve was separated into a coarser and finer portion by washing. The particles of the coarser part of this portion were largely quartz, some felspar and mica grains and also some of the eruptive rock. Such was the mechanical composition of this silt. The chemical analysis gave the following results:

TABLE LVII.—ANALYSIS OF SILT FROM QUEEN RESERVOIR, PROWERS COUNTY, COLO., SAMPLE TAKEN JAN. 23, 1903.

	PER CENT.
Silicic Acid	69.262
Sulfuric Acid	0.080
Carbonic Acid	2.819
Phosphoric Acid	0.120
Chlorin	Trace
Sodic Oxid	1.401
Potassic Oxid	1.807
Calcic Oxid	4.904
Magnesic Oxid	1.081
Ferric Oxid	3.603
Aluminic Oxid	10.428
Manganic Oxid	0.082
Ignition	4.283
Total	99.870

Nitrogen, 0.075 per cent.

§ 129. The elements of plant food contained in this are the potassic oxid, the phosphoric acid, and perhaps the lime and the organic matter. The exceedingly low content of nitrogen indicates that the value of the organic matter is small. This silt differs from the two previously given in carrying a little phosphoric acid. This may come from the rock particles or from the shells, and may be from fragments of bone, a few of which were found in the silt. The chief value is in the potash, forty pounds per ton, but I can see but little difference between this potash, which, for the greater part at least, is contained in the felspar in the silt, and potash contained in any other finely divided felspar. The only question involved is the one of the degree of fineness. The quantity of potash is small, scarcely greater than that contained in an acre foot of some irrigation waters, especially those which have been stored—an acre foot of the Queen Reservoir water carrying 72.3 grains per gallon, and the salts in solution containing 0.5 per cent of their weight of potassic oxid, contains fourteen pounds of potassic oxid, while a ton of the silt carries forty pounds, every whit of which has to be brought into solution. The three samples of suspended matter, or silts, which have been presented represent very different conditions, and yet the composition is essentially the same. We find the mineralogical constituents the same, and essentially the same percentages of potassic oxid in the two from the Poudre, but less in the third, representing the lower Arkansas, and in none of them is it high, 2.9 per cent in round numbers.

§ 130. The fourth sample of suspended matter, of which I shall give an analysis, is of an entirely different nature. This material is not soil, or the natural products of decay on the surface of the crust, but refuse from mills, the products of decay formed in veins, comminuted gangue rock, slimed ore, etc., which is discharged into the water course and carried by the

stream, even to the distributing furrows in the fields. The analysis of this material gave the following results:

TABLE LVIII.—ANALYSIS OF SUSPENDED MATTER IN WELCH DITCH, SAMPLE TAKEN ONE MILE ABOVE GOLDEN, AUGUST 27, 1902.

	PER CENT.
Silicic Acid	53.991
Sulfuric Acid, Sol. in HCl	0.084
Sulfur	1.908
Ferric Oxid	9.420
Aluminic Oxid	15 822
Manganic Oxid	0 636
Calcic Oxid	1 015
Magnesic Oxid	1.613
Zinc	0.383
Copper	0 201
Lead	1 214
Potassic Oxid	4 650
Sodic Oxid	1.057
Loss at 60°	2.386
Loss above 260°	5.495
Total	99.875

Nitrogen 0.121 per cent.

§ 131. The suspended matter amounted to 0.149 per cent. of the weight of the water, equal to 4,056 pounds per acre foot, carrying 4.9 pounds of nitrogen and 190.6 pounds of potassic oxid. This mud is richer in these elements of plant food than the mud of flood waters. The lead, copper and zinc found indicate the presence of 1.402 per cent. of galena, 2.502 per cent. of pyrites, 0.517 per cent. of sphalerite or zinc blende and 0.581 per cent. of chalcopyrite. These quantities of these minerals have escaped the concentrators and failed to be deposited before they reached this point. We have here to deal with a mixture of clay and felspar, a conclusion entirely in harmony with the facts known concerning the concentrating ores in this district.

§ 132. It appears from the results of the examination of these sediments, that they are composed essentially of the finer particles formed by the decay and comminution of the rocks forming the mountains, or rock particles forming the soil, which in our case amounts to saying the same thing. Our soils contain, as their mass analysis shows, a little over two per cent of potassic oxid, 2.2 to 2.6. These sediments contain less than the soils, except in the case of the mud from Clear Creek, which contains about as much as ordinary granite, 4.6 per cent. These results confirm an opinion which I have long entertained, i. e., that there is danger of our overestimating the value of the silts carried by our streams, as it seems almost impossible for this silt to be other than it appears to be from the study of the silts themselves, and the analysis thereof; namely, a mixture of the fine particles of the minerals constituting the mountain masses of the country.

SUMMARY.

1. The general character of the water of our mountain streams is dependent upon the character of their collecting area and is essentially the same for the streams studied in this bulletin.

2 The character of the water changes rapidly as soon as it leaves the mountain section of its course and enters the plains.

3. In the case of the Poudre water, used by the town of Fort Collins, the total solids contained in the water increases from 2.9 grains per imperial gallon, in the mountain section, to an average of perhaps 10.2 grains as delivered to the town, an increase of three and one-third times the original amount present.

4. This change is produced by its flowing through less than eight miles of its course lying within its plains section.

5 The mineral substances held in solution by the water, as mountain streams, are derived principally from the felspars by the action of water and carbonic acid. Pure water attacks these minerals, but its action is greatly increased by the presence of carbonic acid.

6. Our river and ground waters contain both strontia and lithia, which are shown to be dissolved out of the felspars by carbonated waters, and which are therefore to be considered as their source.

7. The amount of mineral matter which the Poudre carries through its canyon daily, assuming a flow of 300 second feet, is nearly twenty-six tons, equal to 520 cubic feet of solid rock, having the average density of quartz.

8. The Poudre water is not nearly saturated, for by direct experiment with finely ground felspar we were able to bring 4.536 grains into solution in each imperial gallon.

9 The composition of the material dissolved out of the felspar by water and carbonic acid, is almost identical with that held in solution by the river water.

10. The organic matter in the river water is not large in quantity and, while probably of vegetable origin, became exceedingly offensive when the water was evaporated to a small volume

11. The waters of the Boulder and Clear Creek agree closely in composition and character with that of the Poudre.

12. The influence of the plains section of the stream upon the character of the water is increased by the irrigation of the adjacent lands.

13. The effect of storage is to increase the mineral matter held in solution. Some of the increase is derived from the ditches through which the water flows and from seepage directly into the reservoirs.

14. A small increase, 0.5 grains per gallon, is due to evaporation, but by far the largest increase is shown in instances where seepage water is either intentionally stored or flows into the reservoir.

15. In the case of Terry Lake the total solids found in two different years were 134.5 grains and 175.6 grains per imperial gallon. The average of which shows that this lake held in solution 27,127 tons of solids in its 9,000 acre-feet of water.

16 Windsor Lake, containing 14,000 acre-feet, held 18,894 tons in solution.

17. The water with which these reservoirs were filled was taken, for the greater part, directly from the Poudre, and the rest of it indirectly, it having in the meantime passed into the soil and reappeared as seepage.

18. The mineral matters held in solution in the different reservoirs differ considerably. Those of Terry Lake resemble in their composition

the alkali incrustations, which appear in many localities; those of Long Pond and the Windsor Reservoir resemble the water soluble portion of the soil, rather than the efflorescent alkalies. The water of Warren's Lake has suffered less change in the character of the salts held in solution than the others, and yet, the sulfates compose rather more than 50 per cent. of the salts held in solution.

19. The salts predominating in the water of the Poudre, while it is a mountain stream, are the carbonates, with some chlorids and sulfates, but as, stored in Terry Lake and Windsor Reservoir, the carbonates have almost disappeared and their place has been taken by the sulfates.

20. The amounts of calcic magnesic and sodic sulfates which appear in the stored waters are large. We find in Terry Lake 5,859 tons of calcic sulfate, 10,616 tons of magnesic sulfate and 7,113 tons of sodic sulfate. In the Windsor Reservoir we have the same salts, but in different quantities, 6,083 tons calcic sulfate, 7,029 tons of magnesic sulfate, 1,999 tons of sodic sulfate. These are the salts which constitute our alkalies.

21. The only constituent contained in these stored waters which, under our conditions, may have any great interest or significance as a plant food, and consequently tend to maintain the fertility of the soil, is the potash, K_2O. The quantity of potash held by the stored waters is not great. The aggregate amount present in the four lakes discussed is 188 tons, contained in 27,672 acre-feet of water, which, allowing two acre feet of water to an acre of land, would give an application of fifty pounds of sulfate of potash to the acre, which undoubtedly tends to maintain the fertility of the land to which it is applied

22. The potash contained in the stored waters is largely brought into the reservoirs by seepage or other than river water.

23. The application of two acre-feet of river water as it flows through the canyon would give only 12.5 pounds of sulfate of potash per acre, or exactly one-fourth as much as the stored waters. As the seepage water contains not more than one-third of the latter in either of these cases, it follows that the amount of potash carried by it and neccessarily obtained from the soil through which it has seeped, is much greater than that carried by pure river water, and we may note that the quantity indicated is greater than that carried by drain water or by soil water, as a rule, but is less than that carried by off-flow water, and sometimes by soil water.

24. The amount of nitrogen, including all forms, added with the irrigation water, being less than four pounds per acre, is negligible.

25. The quantities of useless, or even deleterious salts, added to the soil by the application of two acre-feet of stored water to an acre of land, are worthy of consideration. In the case of the Windsor Reservoir we add the equivalent of 54 pounds sulfate of potash, and at the same time 5,347 pounds of other salts; in the case of Terry Lake we add 55 pounds of sulfate of potash and 11,349 pounds of other salts.

26. Water used in direct irrigation, that is, water conveyed by means of ditches directly from the river to the land irrigated, suffers less change than when stored, but does not by any means escape altogether. The best measure that I have of the extent of this change, and one which, judging by the extent that the water supplied to Fort Collins is changed in flowing less than eight miles, is not an extreme or an exaggerated one, indicates that the total solids are not less than five times as much as in the river water when the ditch was not more than ten miles long.

27. The water used in irrigating, in order to study its changes, was water taken directly from the river, so far as we could obtain such. The general results may be stated as follows:

28. The water flowing over the soil carries, in the first portions which flow off, very considerable amounts of salts in solution. The samples which gave the most reasonable results indicated that water flowing for 600 feet over the plot experimented with, carried between 800 and 1,000 pounds more salts in solution, per acre foot, than the on-flowing

water. The first water that flowed off gave much higher results, but subsequent samples showed a rapid falling off.

29. The water entering the soil caused the solution of not less than 4,400 pounds of salts per acre-foot, and probably very nearly three times this amount.

30. The salts taken into solution by the water entering the soil and becoming ground water, are calcic, magnesic and sodic sulfates. The salts dissolved in the next largest quantities were sodic chlorid and sodic carbonate.

31. The amount of salts brought into solution in the ground water, due to the application of water to the surface, varies not only in the total amount of salts, but also in the relative quantities of the individual salts. The salt that went into solution the most freely in 1898, that is, the salt that showed the largest increase in the ground water, due to the irrigation of the plot with which we were experimenting, was sodic sulfate, for which we found an increase of 1,430 pounds in each acre-foot of ground water. In 1899, the largest increase was shown by calcic sulfate, an increase of 1,638 pounds per acre foot.

32. In 1898 there were two causes which may have contributed to bringing about the relatively large increase of the sodic sulfate. One was the scanty supply of water, which did not enable us to fill the soil with water to the same extent that we did in 1899, so that the relative mass of water to that of the soil, or to the salts in the soil, was not the same. This is an important condition and one, for the effect of which we have no measure. The other was the necessity that we were under of excluding the water of well D. from our consideration of the results of this irrigation, because of an accident. The results shown by this well subsequently indicate that it would have showed a greater increase in the amount of calcic sulfate than the other three, and would consequently have reduced the relative increase of sodic sulfate. The general results were slightly influenced by this omission. Still, after all due allowance for these facts has been made, there remains a decided difference in the results of these two experiments, one in 1898, the other in 1899.

33. The character and supply of the water exert an influence upon the relative quantities of the salts that go into solution, but there are evidently other factors that influence these ratios. The general conditions of the soil, the temperature and the season of the year, including all the meteorological conditions, probably have a great influence upon the salts in the soil, and the relative quantities of them in solution in the ground water.

34. The effect of a long continued rain in the spring of 1900, when the temperature of the water entering the soil was not far from zero, as the ground was covered with melting snow, is given in Tables XXXVI, XXXVII and XXXVIII. The salt present at this time, April 9, 1900, in well A, in the largest quantity, was magnesic sulfate. The quantity of this salt present, on this date, was between four and five times greater than the average quantity present during the season of 1898. The quantities of calcic and sodic sulfates were also greater than their respective average quantities for the same time; that of calcic sulfate was one-third higher, while that of sodic sulfate was between five and six times greater. The increase of the sodic sulfate over its average quantity for 1898, is greater than that of the magnesic sulfate, but the amount of the former salt present is just a little more than one-half that of the latter.

35. The following general conditions may have contributed in bringing about these variations. The weather during the preceding weeks, or even months, also the abundant supply of water simultaneously over a large area. I conceive this last condition to differ very greatly from the application of even a copious irrigation applied to a limited area of soil.

36 It is a common observation that the alkali salts effloresce freely during the winter season. It may have been the case in this instance that an unusual amount of this salt, magnesic sulfate, had accumulated in the upper portions of the soil, owing to evaporation during the preceding winter. Such a result is suggested by the presence of this salt in

large, sometimes predominating quantities, in the effloresced alkalies, but I have no other observed fact to support it.

37. The very large quantity of magnesic sulfate present may also be accounted for by supposing that the ground water, under the then obtaining conditions, actually dissolved larger quantities of this salt out of the soil than of the others.

38. It is not clear from any facts which I was able to discover, to which of these conditions, if to any of them, the observed fact ought to be attributed; to the accumulation of the magnesic salt in the upper portion of the soil, due to evaporation from the surface and the consequent action of capillarity, to low temperature, to the abundant supply of water over a large area, or to some other unrecognized cause.

39 The fact is simply this, that the salts in the ground water are essentially the same at all times, and the application of water to the surface, whether it be irrigation water or rainfall, does not change in any material way the salts present. The relative quantities in which they are held in solution in the ground water varies quite widely, while the causes of the variations are not evident. It is not probable, for instance, that the quantity of magnesic sulfate in the soil experimented with, predominates at any time over the calcic sulfate, as the relative quantities of these salts found in the ground water in the spring of 1900 might be held to suggest. The solution obtained by thoroughly exhausting this soil with water, shows that there is from two to three times as much calcic as magnesic sulfate in the top four inches of it. The total lime contained in this soil, as shown by analysis of the whole soil, is in round uumbers, double that of the magnesia. The lime in the hydrochloric extract of this soil usually exceeds the magnesia; in the subsoil it is even eight times as great.

40. The ground waters, under ordinary conditions, always contain more calcic than magnesic sulfate, but under the conditions prevailing during the spring of 1900, we find the rule reversed—see analyses XXXVI, XXXVII and XXXVIII. The cause, or causes, of this were evidently not permanent, for within a period of eight days we observe a change, in which the ratio of magnesic to calcic sulfate, in the water of well A, falls from 2:1 to 1.2:1, a ratio which had already been found for these salts immediately after irrigation. In the drain water taken on the same date, April 20, 1900, we observe the usual ratio between these salts. The drain water is at all times different from the ground water, and too much stress should not be placed upon the ratio of these salts observed in it. Its chief value, in this case, is to show that, though the conditions in regard to temperature, water supply, etc., were general, they have produced no noticeable effect upon the kind or relative quantities of the salts carried in the drain water.

41. The water of well A, on April 9, 1900, was intermediate in the character of the salts held in solution between the alkali-incrustations forming on this soil, under favorable conditions, and the water usually present in the well. It differed from the former in having less sodic sulfate, and from the latter in carrying less calcic sulfate and very much more magnesic and sodic sulfates. These facts do not seem to be in any way dependent upon the solubilities of the salts themselves, nor upon any known state of hydration.

42. The quantities of potash involved were not large, being 15.1 and 19.2 pounds respectively, for the two seasons, 1898 and 1899. These quantities are extremely small, when we consider the mass of other salts which was brought into solution. In 1898 we have nearly 2.25 tons, in 1899, 2.5 tons of salts brought into solution, and this on plainly too conservative an estimate, while only these small quantities of potash are carried along with them. If we were to treat an equal amount of ground granite with this amount of water, it would dissolve out more potash than is here shown to have gone into solution, notwithstanding the tendency of such a large quantity of salts, 2.5 tons, to carry others into olution. This is entirely in accord with facts observed long

ago, i. e., that the soil retains potash salts more tenaciously than it does others.

43. The drain waters, as indicated by such data as we have been able to gather, though we have not been able to study this subject as we desired, differ materially from the ground waters. They contain a smaller quantity of salts in solution, and are more uniform in this content than the ground waters. The salts present stand in a different order, especially in regard to their relative quantities, sodic sulfate sometimes disappearing entirely. Calcic sulfate is uniformly first in quantity; magnesic second, sodic carbonate third, and sodic chlorid fourth, with sodic sulfate quite irregular, but usually less than the sodic chlorid.

44. The first significance of these facts is that our drains benefit our lands by removing the surplus water, rather than the useless or deleterious salts, from the soils. This is by no means a small service. Indeed, it is the most important service to be rendered to nearly all of our alkalized land. Of the salts removed, the most injurious one, when present in sufficient quantity, is the sodic carbonate. Relative to the amount of this salt present in the drain and ground waters, a comparison of the analyses of the drain waters with those given of ground waters in this Bulletin, and also with those in Bulletin No. 72, pages 23-26, it will be seen that the grains per gallon remain quite constant. In other words, the sodic carbonate does not seem to be retained by the soil, or removed from solution by passing through it, while the sodic sulfate, or white alkali, is retained to a very marked extent.

45. The only samples of drain and ground waters taken on the same date, are those taken April 17, 1900. The samples of ground water are unusual, as set forth in preceding paragraphs, but the features to which I wish to call attention are so bold that they will not be hidden, or even distorted by these facts. In the ground waters we have 452 and 470 grains respectively, in the drain water 114 grains of total solids. The sodic carbonate in the ground waters amounts to 26 and 22 grains respectively in the drain water 23 grains. The range of this salt in the ground waters, given in this Bulletin, is from 10 to 28 grains per imperial gallon, and in those given in Bulletin No. 72, it is from 9 to 18 grains, while the range of the same salt in the drain waters given in this Bulletin is from 11 to 23 grains. Returning to the samples of April 17, we have in the ground waters 76 and 115 grains of calcic sulfate per gallon, for the drain water 45 grains. We have 152 and 137 grains magnesic sulfate per gallon for the ground water and 24 grains in the drain water. Still more marked than either of these is the case of the sodic sulfate, of which we have 105 and 89 grains respectively in the ground waters, and 5 grains in the drain water. The sodic chlorid is also retained within the soil, but in a less degree than some of the other salts. The ground waters on this date, April 17, 1900, carried 56 and 64 grains respectively, while the drain water carried 7 grains per gallon, or one-eighth as much as one of the samples and one-ninth as much as the other.

46. The analyses of the ground water before and after irrigation show that one of the effects of irrigation is to rather increase the relative amount of sodic chlorid in the ground water, so that the above figures appear more favorable to my statement than the facts as they are found, under less extreme conditions, might appear. Reference to the analyses of ground water, given on pages 30-33 and 38-40 of this Bulletin, and to those given on pages 21-26, Bulletin No. 72, will show that the sodic chlorid in the drain waters is less than in the ground waters, under the wide range of conditions represented by these numerous samples. Some of the analyses referred to, especially some of those in Bulletin No. 72, suggest very pointedly that the character of the soil has a decided influence upon these points; the indications being that the soil experimented with permitted the respective salts to pass through more freely than soils freer from alkali salts, and in better mechanical condition, would have done.

47. The amount of potash salts removed by the drain water is less than that existing in solution in the ground water. The total amount removed in the course of years is a large one and, while we are reminded that the draining is going on all the time, day and night, year after year, we have to consider also that potash is not taken from any single acre-foot of soil, nor from a mass represented by a single acre of surface, but for the sake of keeping our numbers within limits which we can appreciate, I will give the figures showing the amounts of potash, on the basis of the acre-foot. One acre-foot of our soil contains a total of 78,750 pounds. Of this dilute hydrochloric acid dissolves 43,750 pounds. An acre-foot of ground water, before irrigation, in 1898, contained 22 pounds, and in 1899, 6 pounds of potash. After irrigation, in 1898, it contained 41 pounds, in 1899, 18 pounds. An acre-foot of drain water carries but 5 pounds, taking the average of four drains. The water draining from any given acre of land is probably small, not exceeding a hundredth of an acre-foot daily, in which case the amount removed from any single acre of land is very small. We will put this another way, in which the statements may seem more definite. If we take a strip of our land 18 miles long and one mile wide, from which there is discharged 30 acre-feet of drainage water daily, it would take upwards of 50,000 years for it to carry out an amount of potash equal to that contained in the first three feet of soil.

48. The nitrogen carried by the drain waters is only a little more per acre-foot than the potash, it being 5.8 pounds. The supply of nitrogen in the soil is not so great as that of the potash, by any means, but while there is no accession of potash, except it be added, there may be of nitrogen. The amount found in the first two acre-feet of our soil was 7,000 pounds, and it would take 1,227 acre-feet of drain water to contain this much nitrogen.

49. The return waters furnish us a bigger and slightly different measure for the effects of drainage, and as this, with us, is mainly due to irrigation, they furnish us, perhaps, the best criteria by which to judge of the effects of irrigation upon our lands. We would expect to find their composition very similar to that of the drain waters, provided our samples of drain water were numerous enough to represent the various soils and conditions to be met with in the 176,848 acres of land nominally under irrigation within this valley, of which probably 140,000 are actually irrigated. This remark applies, of course, to the Poudre Valley and river.

50. We find the total solids in the return waters lower than in the ground waters, and having the same range as found for the drain waters. We find them characterized by the same salts, and in the same order in regard to their relative quantities; i. e., calcic sulfate, magnesic sulfate and sodic carbonate, with sodic sulfate irregular in its quantity, but always subordinate, except in the sample of Arkansas river water, taken at Rocky Ford, April 24, 1903, concerning which some doubts may be entertained, but which is probably correct, because the ground waters of that section are extremely rich in sodic sulfate.

51. The salts discharged by the Poudre into the Platte river do not amount to less than 22,000 tons annually, which come from the lower section of the river, besides what may be carried from sections further up the river when the waters are not all taken out, as was the case at the time our samples were taken.

52. The chief difference between the drain waters and the return waters taken from the rivers, is in the potash present, which is greater in the return waters than in the drain waters. While some of the drain waters contain almost as much potash as the return waters, the latter are, as a rule, richer in potash than the former. The main features of these two classes of waters are, however, identical.

53. The waters of other streams, which we examined fully, justify us in assuming that the Poudre river water is typical of the mountain waters on this side of the range. They show that the waters of the different streams, while in their mountain sections, are identical; that all

alike suffer changes on entering the plains, and their return waters, as represented by the Platte river below the mouth of the Poudre, indicate that the changes suffered by them are, in all essential particulars, the same.

54. These mountain waters are interesting and worthy of fuller and more detailed study than is proper to devote to them in this place. Therefore the discussion of them will be omitted, except one feature of the Clear Creek sample. Clear Creek presents an instance of a stream whose waters are laden with the mud and slimes from many mills, and whose waters are also used for irrigation. The sample analyzed was taken from an irrigation ditch. A full and careful analysis was made of it, a fuller and more careful one than would probably have been made in the case of a legal controversy, and yet it shows nothing that can be interpreted as a serious pollution of the water. The essential characteristics of a pure mountain water have scarcely been modified in the least. The purest mountain water in any of these streams carried 2.6 grains per imperial gallon, Poudre river water, sample taken July 30, 1902. The sample of water taken from Clear Creek, a stream which drains a section of country with a population of at least 25,000 souls, and receives indefinite quantities of mine water, and the refuse from twenty odd mills, carries less than eight grains to the imperial gallon, an increase which is less than that caused by a flow of a few miles (four to eight) in the plains section. Of the heavy metals, salts of which we might expect to find in this water, due to oxidation of the ores treated in the mills, we find none, a trace of zinc oxid, 0.0157 grain in each imperial gallon, excepted.

55. The suspended matter in our streams and ditches was found to be very much less than was expected, even in time of flood, due to heavy rains in the lower and, largely soil covered sections of the mountains, or in the foothills. The water, at the time the first sample given in the text was taken, corresponded to the colloquial expression, "as thick as mud." The season was one of high water, when the usual flow is 1,200 second-feet, due to the melting of the snow, but at this time it was ten times as great, or 12,000 second-feet. The rain fell in a hilly section and the fall of the river being great, we had conditions favorable to the tearing loose of soil, rocks and other debris. The crest of the flood had not passed at the time the sample was taken, and the amount of suspended matter in this sample probably represents the maximum that we may expect to find in this stream at any time. The amount of sediment equalled 3 tons per acre-foot of water. The aggregate amount of sediment carried by such a flow, 12,000 second-feet, laden as this was, is not far from 2,800 tons per hour, all of which, it is true, must sooner or later be deposited somewhere, and in considering this as a source of fertility we permit the impression of this big aggregate, and the fact that it is deposited somewhere, to lead us to form too high an estimate of its actual available amount, and we at the same time assume that it is feasible to apply it to the land. If it were feasible and we applied two acre-feet of it to an acre we would add six tons of this suspended matter to the acre. This would, if spread evenly over the surface of the acre, form a coating less than 0.04 of an inch in thickness, or twenty-five such floodings would, under very favorable conditions, furnish a dressing of this sediment one inch in thickness. This would, of course, if rich in plant food, be a very desirable addition to the acre of land. There are, on the other hand, several considerations to be weighed before we set this gain down as an easily attainable fact. It is not a fact that we can apply this muddy water to our land when it is in the river, and the occasions when it is in the river are very seldom; this one scarcely having been equalled since the occupancy of this valley by the white man, except once, when it was due to the breaking of a dam. The facts on which the assumed supply of sediment is based, are wholly exceptional. But if we grant the supply, the question of value is an open one, and here, as in the question of quantity, we permit our judgment to be imposed upon. In that case the large total, and the fact that it is deposited, leads us to the

conclusion that it is deposited in large quantities on the soil we have in mind. In this case the color and fineness of the sediment make a general impression of richness upon our minds, and we forthwith accept it as an established fact when it is not. The composition of this sediment does not justify the inference.

56. This sediment, very naturally, resembles in composition the source from which it was derived, which was the soil of the mountain or hillsides and their valleys. These soils have a common source with those of the plains, and it is therefore, on reflection, no matter for surprise that the sediments should not be found to be richer than the latter. There are two respects in which the sediments, in some measure, differ from the soils on which they would be deposited in our case, but this measure is not very great. These two respects are the fineness of division and the amount of organic matter contained in them. The fineness of the sediment is a condition favorable to the alteration of those mineral particles containing elements of plant food, whereby these latter are made available. The amount of organic matter contained is larger than in the average of our plains soil, but is not large when considered by itself. The case resolves itself to about this, that the 0.04-inch of sediment, which an application of two feet of water to an acre of our soil would add, would be equivalent to adding a layer of the same soil only a little more uniformly fine and containing a little more organic matter.

57. The sediments from the ditch waters are of the same character, and resemble more closely still, the soils to which they would be applied with the water.

58. Another sample of sediment examined was one which had been carried by flood waters and deposited as silt in a reservoir, the Queen reservoir, Prowers County, Colo. The mineralogical and chemical composition of this suggests the same considerations, and points to the same conclusions that I have endeavored to set forth in discussing the sediment carried by the flood water of the Poudre. This sediment, however, is less suggestive of the probability of any considerable benefit accruing to the land by its application to it.

59. The fourth sediment examined was of an entirely different origin, and naturally of a different character, and certainly ought to be looked at from two different and opposite points of view. The practically more important one being in regard to the possible injurious effect which any minerals present in it might have upon the vegetation to which it might be applied with the water. The other point of view is the same as that from which we have briefly considered sediments carried by our streams in general.

60. The analysis of the sediment answers the question relative to the presence of minerals, either injurious in themselves, or by the products of their decomposition, in the negative. The amounts of sulphid of lead, zinc, copper and iron do not exceed 35 pounds per ton of sediment, or if the whole of the sulfur found were present as iron pyrites, probably the most dangerous form in which it is likely to be present, the total amount would be 43 pounds per ton, about 86 pounds per acre-foot of water, a quantity, of itself small, and which can be reduced by the use of settling ponds, or other settling devices.

61. From the second point of view the quantity is not only materially in excess of the quantity carried by our streams in times of ordinary high water, but actually carries more potash, nitrogen and organic matter, the former constituting the principal value in either case.

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Irrigation Waters and Their Effects.

—BY—

WILLIAM P. HEADDEN.

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IRRIGATION WATERS AND THEIR EFFECTS.

BY W. P. HEADDEN.

I shall endeavor to set forth in general terms some of the broader features of the questions pertaining to the changes caused by irrigating our lands, without making any attempt to go into details, or any pretense to a thorough discussion of the questions connected with this subject. The following pages are intended as a brief or popular bulletin, presenting some of the conclusions arrived at in bulletin No. 82, but are entirely independent in the manner of presentation.

The waters used for irrigation in earlier years were really derived directly from the melting snows of the mountains to a much greater extent than at the present time. The cold of the higher altitude of the mountains was then the only cause preventing the waters falling in these regions, or formed by the melting of the snow, from flowing rapidly from the place of their precipitation to the lower reaches of the rivers, through which they find their way to join the oceanic waters. This agent is as active now as then but alone it is inadequate to effect a sufficiently regular distribution of these waters to meet the varied and growing requirements of agriculture, and it has been supplemented by the use of reservoirs to store the waters and prevent them from going to waste. Not only has the attempt been made to store the flood

and other surplus waters in order to subsequently distribute them, that they might add to the well-being and prosperity of those living in sections further down the stream, but our agriculture has so increased that much more water is required than formerly, and in order to meet this requirement our reservoir systems have constantly grown. All available sources of water are rapidly being made to render service, until the waters of the mountains are taken out of the streams and returned several times, before being finally discharged into the bigger streams of which their natural channels or smaller streams are confluents. We may yet learn to further increase the duty of water, but if we do we will not lessen the questions relative to the changes produced and suffered by these waters used for the purposes of irrigation. We will, on the contrary, intensify them and probably find that new questions will be raised.

It is well known, but still more generally accepted as a fact, that the waters of rivers rising in high mountains where there is little soil, a scanty vegetation and no human beings to pollute them, are comparatively pure, many of them very pure indeed. This is the case with the waters of our mountain streams and is not a fancy arising from the notions which we associate with the mountains and their seclusion. The rocky face which their surface so generally presents does not wholly withstand the attack, gentle though it seem, of the falling rain or melting snow. The rocks yield little by little it is true, but the water is never able to enrich itself greatly in mineral matter at their expense. The work done by the waters in a year, a month, or even in a week, when measured in the aggregate is surprisingly large, but no given quantity of this water, a gallon or so, carries more than an infinitesimal part of the product. This water is usually colorless and free from organic matter because we have no accumulation of decaying organic matter such as peat, etc. to contaminate it. Where the surface is covered with soil there is little difference between the soil and the rocks on which the soil rests. I do not know whether the changes which take place in this soil proceed more rapidly than in the rocks proper or not; it is presumable that they do, but they are essentially of the same kind and this is true throughout the mountain region. These waters suffer little change so long as they continue to flow over the rocky beds which they have cut for themselves in the flanks of the mountains, or so long as they move through the soils which are little more than the pulverized rock on which they lie. This, however, is no longer true when they issue from the mountains and enter the plains.

We think of water flowing in a stream as being the same water that it was at its source. In a certain sense it may be, but if we apply this to mean that the water in our streams after they

have issued from the mountains is the same in the quantity and character of the salts that it holds in solution as before, we err and are confronted by a series of facts that prove us to be in error. There may be occasions when the pure waters of the mountains are carried further down their course before they suffer changes than under normal conditions, but that they subsequently fall a prey to the general lot is beyond question.

If flood conditions prevail and the level of the water in the stream is higher than that of the water in the country through which it flows, in which case the velocity of the flow will also be increased, the purer, though turbid flood waters, may flow for miles further down the stream without being perceptibly changed than is the case when the flow of the stream is normal. This question might be of importance and certainly would be an interesting one to study, but the writer has never had occasion to go into this detail of the study of flood waters.

If we think of the water of a stream as a body of water flowing through a channel whose sides and bottom have no influence upon the water, just as though the water were flowing onward through a flume, we misconceive the facts. The sides and bottom, or bed of the stream are not only not tight but they are in places full of water that they discharge into the river. At others they present conditions permitting water to flow from the river into the bed and so disappear. The stream may lose water by evaporation from its surface and by leakage. The latter loss is often very considerable. These facts which are common subjects of discussion in our state suggest sufficient causes for the changes in the waters of our streams upon their issuing from the mountains into the plains. Our climate is comparatively dry but our soils are not devoid of water. The fourteen and one-half inches of rainfall may largely run off, and some of it be lost by evaporation from the surface. There is, however, a sufficient supply stored in the soils, valleys, and the marginal territory of streams to supply enough water differing wholly in character from that of the mountain streams, to modify the composition of the latter and to perceptibly change its character very soon after, if not immediately upon its leaving the mountains.

The mountain masses represent very old rocks which have been changed into schists and granites. Lapping upon the flanks of these are younger and different rocks, some of the latter being made up of fragments of the former. The water gathered within the mountains carries some mineral matter that dissolves out of the rocks, but this amount is not great and its character is very uniform throughout this section. The amount and character of the mineral matter is rather a benefit than a detriment to the water, it not being sufficient to change its character as soft water.

Upon its entering the plains it begins to receive an increased amount of mineral matter and we soon find from four to more than seventy times as much and the water passes from a soft, mountain water to a hard, alkali, plains water. This change can be detected within a short distance of the point where the streams leave the mountains.

The water then that we use for irrigation rarely has the same purity that it possessed in the mountains. In one experiment I found that in flowing about ten miles through a ditch, the mineral matter carried by the water increased fivefold. This mineral matter came, of course, from the land adjacent to the ditch.

In our natural waters, those of our mountains, it is proper and in perfect accord with what we would expect, that they should contain corbonate of lime, magnesia, etç. and we find such to be the fact, but as soon as they pass into the plains section of the stream they begin to exchange these for the sulfates until these latter become the predominating salts. In the meantime the three grains per gallon in the mountain water have become 100 grains per gallon in the plains water. This is not an exaggerated statement, but one far within the limits of fact. The water of the Cache la Poudre carries in the mountain sections of its course 2.9 grains of mineral matter per gallon, and just above Greeley, 115 grains, the carbonates constitute nearly 40 per cent of the former while magnesia sulfate, Epsom salts, constitute nearly one-third of the latter. Almost the same statement can be made of the Arkansas, at Canon City, the river water carries say 10 grains per gallon, below Rockyford 156 grains. The carbonates constitute 50 per cent. of the former while Glauber and Epsom salts constitute 40 per cent. of the latter.

In neither of these statements have I taken any account of the calcic sulfate. It is difficult to judge how much of this change is directly attributable to irrigation. Irrigation may exaggerate these changes but that they would take place in a large measure if there were no irrigation is indicated by the fact that they begin immediately, so far as we can see, upon the waters leaving the mountains, and also by the changes in the water in ditches above which there is but little or no irrigated land.

The cause of these changes is the entrance of water from the land adjacent to the river course, or return waters.

In order to hold the flood and other waters until they can be applied to crops and be made beneficial to the country, large reservoirs have been established and the river waters conducted into them and retained there for varying periods. These reservoir sites are depressions capable of having their holding capacity increased by embankments thrown up or built in the proper place. They

must be above the land to be irrigated and are not as a rule in low places, but they are natural collecting basins, many of them having been small lakes before they were converted into reservoirs. These conditions suggest that they might now receive larger quantities of seepage water which in some instances is undoubtedly the case.

These stored waters sometimes suffer as great changes as the river water. It is understood that the water stored is taken from the river, much of it directly and some of it, the seepage water, indirectly in that this water has been taken from the river, applied in irrigating land and has reappeared as seepage water. A small portion has fallen as snow or rainwater.

In studying the changes in the reservoir waters it is not easy to determine just how much is to be attributed to the several causes contributing to them. If the waters were found to be quite pure, with an increase of only 0.5 of a grain per gallon, the gain could justly be attributed to evaporation from the surface of the reservoir. This would be the exact amount in the case of Terry lake. But we find an increase in this instance of upwards of 130 grains per gallon instead of 0.5 of a grain and the amount of salts indicated by this small amount, 0.5 grain per gallon, can be wholly neglected without affecting our final results in the least. The only rational explanation that we can offer for this increase is the seepage, together with whatever quantity of soluble salts may be furnished by the bed of the reservoir.

The amount of salts actually present in some of these reservoirs is rather surprising to the layman, and to others too, who are not cognizant of the facts in the case.

In the instance of Terry lake, which presents the most striking results of the four reservoirs which I have studied in anything like detail, the amount of salts held in solution was in round numbers 27,000 tons. The samples on which this estimate is based were taken just before they began to draw off the water and I think were as good as could be gotten. A volume of Poudre river water equal to the content of Terry lake, 9,000 acre-feet, would contain about 500 tons of mineral matter, leaving 26,500 tons as having been brought in by seepage. The other lakes, reservoirs, examined gave smaller figures but indicate the same general fact.

A peculiar fact is that there was a slight increase in the percentage of potash which, for reasons that would take too much space to enter into in this place, we believe to indicate that much of this increase was due to the solution of alkalies by waters flowing over the surface of seeped ground.

The changes which took place in this instance are so patent that they cannot be misinterpreted; the carbonates, relatively

abundant in the residue from the river water, have almost disappeared, and we have in their stead sulfates, Glauber and Epsom salts forming 65 per cent. of the total mass. All the reservoir waters studied show the same changes, but Terry lake alone shows it in this extreme degree. Windsor reservoir, however, shows it in a very high degree, only a little less than Terry lake.

The water that is applied to the land then can be said to be of two classes, river water taken for direct irrigation and such as has been stored. Of late years measures have been taken to utilize waste and seepage water wherever available. This may differ a little from the stored water but so far as my knowledge goes it is seldom more heavily laden with mineral matter than the water of Terry lake and we need not consider it as making a separate class.

The amount of mineral substances carried by the river water before it leaves the mountains, which is available as plant food, is very small, 6.25 pounds of potash per acre-foot and the amount of other salts added with such water is of no moment either way. But the water taken for direct irrigation seldom reaches its destination without receiving a decided addition to its stock of mineral matter and a considerable increase in the potassic oxid carried by it. As the question considered relates to the land to which the water is applied, the source from which the potash is obtained is not considered but simply the fact that it is contained in the water as applied to the soil. The amount of potash in the river water ,as distributed on the field, was greater than we have found it to contain as mountain water, almost twice as much, but it was not a large quantity, only 11.6 pounds per acre-foot. This water as a fertilizer was not of much value. It may have been worth 50 cents per acre-foot. Neither did it carry salts which in any reasonable quantities would prove deleterious. The benefit derived from the application of this water is from the application of the water as such and not from any mineral matter held in solution.

The value added to this water by the presence of organic matter and any nitrogen contained in it is also very small, in fact as good as nothing, between 60 and 70 cents per acre-foot. While we do not add any considerable quantity of directly fertilizing salts there is nothing added in sufficient quantities to diminish in the least the good that it does. Is the same the case with stored waters? We can give only a tentative answer to this question. Our soils contain soluble salts whose influence upon our crops is, to say the least, of doubtful benefit, and to add more of the same sort would not seem to be very wise. We have given the capacity of Terry lake as 9,000 acre-feet and its content of salts as 27,000 tons, all of which is distributed with the water, or allowing one

foot of water per acre it would add three tons, 6,000 pounds, of these salts. If the potash contained in this quantity of salts were present as sulfates, it would weigh 27 pounds. The remaining salts, 5,973 pounds, are either indifferent or when present in large quantities, undesirable. I have used Terry lake as an example in order to present the question which, as every one will see, is further raised by the use of seepage water.

If these salts are not deposited on or in the soil the question relative to their influence is reduced to one relative to their immediate effect upon the plants.

The salts present in Terry and Windsor lakes are calcic, magnesic and sodic sulfates with very little carbonate, probably sodic carbonate. These two lakes or reservoirs probably represent the greater part of the stored water used for irrigation and the rest will be represented by Long Pond and Warren lake water, which carries relatively more sodic carbonate and less sodic sulfate.

The seepage water that I have examined has varied considerably, a result which was to be expected, but the general composition of the mineral matter held in solution by these waters is fairly represented by the salts found in the stored water. The seepage water in sections where irrigation is not general and the supply of water not abundant, is heavily charged with salts, calcic, magnesic and sodic sulfates, the last being strongly predominant. On the other hand samples collected under different conditions have been found to carry smaller amounts of soluble salts in solution than some of the stored waters, and the salts present were calcic and magnesic sulfates together with carbonate, probably sodic carbonate. These statements are sufficient to set forth the composition of these waters and their similarity in a very rough and general way.

General statements are to be found of the effects of these salts on plants, but it would be more satisfactory if we had series of experiments giving us, conclusive results as to their detrimental or perhaps beneficial effects, when present in known proportions. This question is of interest to us and may become more so, but it has not been of such general interest as to lead to the making of tedious experiments to determine it. The tolerance of these salts by ordinary plants, sodic carbonate excepted, is probably far beyond the limit to which they are at all likely to accumulate in our soils.

The samples of soils which I have found to be richest in alkali salts yielded upon extraction a little less than 4 per cent. This was beyond the limit at which we successfully cultivated plants but we succeeded in soil, the surface portion of which showed one-half this amount or 2.0 per cent., but taking the first four inches of soil there was only 1.4 per cent. The salts found in

this case were calcic, magnesic and sodic sulfates principally. The distribution of salts in the soil has an important bearing upon this question. These observations were not the results of prearranged experiments but indicate just as certainly as though they were, that large quantities of these salts may be present in the soils, other conditions being favorable, without precluding successful cropping.

If these figures be nearly correct, we can have in the first foot of soil as much as 25 tons, but probably not more than 50 tons of these salts, the mechanical condition of the soil and the drainage being good, before the salts become decidedly injurious. Accepting this maximum which is tentatively given as approximately correct, and based upon a limited experience, we may get a clearer view of the importance of this question. Taking a water as rich in mineral matter as Terry lake water, carrying three tons of salts in each acre-foot, we see that the application of nine acre-feet would add an amount of salts in excess of our lower limit. These salts would have been applied at the surface of the soil in nine successive portions, and unless it were carried down into the soil with the water, would already appear as an incrustation, especially under favorable weather conditions.

There is no doubt but that the soil does, as it were, strain out some of these salts, but it takes a thick layer to accomplish this. It would be difficult to explain how this is done but the soil particles hold on to these salts in some way and do not permit all of them to pass through the soil with perfect freedom. Indeed it is not probable that it permits any of them to pass through with perfect freedom but it retards some more than it does others. These salts are not collected within the first foot of soil, nor within the second, but may pass down several feet before they are stopped, so that, while there may be an addition of these salts held in solution in the water, as there evidently is, the addition is not necessarily to the surface soil, though the water is applied there. There is another thing that helps us in this case. The soil selects the salts which it retains and it seems to permit the most dangerous ones to pass through it more readily than some others. The ratios of the salts in solution in the water as it is put onto the ground, while it is in the ground, and as it flows out of the ground, are not the same. We cannot attempt to discuss this subject. The following statement is by no means perfectly accurate but it will serve roughly to show how the sodic carbonate, for instance, is permitted to pass through the soil more readily than the sulfate.

In an experiment which we made we found that an acre-foot of irrigation water contained 438 pounds of sodic carbonate, the water in the soil at a depth of from two to four feet contained 543

pounds and a like quantity, an acre-foot, of drain water contained 895 pounds. The water in the ground contained 868 pounds of sodic sulfate while drain water contained 168 pounds in an acre-foot, Evidently the sodic carbonate has passed out of the soil much more freely than the sulfate. If the sodic carborate were retained unchanged by the soil the result would be most unfortunate. This sodic carbonate is none other than "black alkali." We will take an irrigation water, such as we found that of Warren's lake to be in 1902, an excellent irrigation water with only 26 grains of mineral matter in each imperial gallon. We find in this 88 pounds of sodic carbonate per acre-foot, or the application of 20 acre-feet would add 1700 pounds of anhydrous sodic carbonate to each acre of land. Experiments made some years ago led me to conclude that if there were as much as 1750 pounds of sodic carbonate per acre, taken to a depth of one foot, it would under ordinary conditions kill young plants such as beets, etc. If the soil retained the sodic carbonate within a foot of the surface without changing it in any way the result would be that the soil would be rendered perfectly useless. The soil fortunately does not retain this, the most dangerous of alkali salts, but permits its passage rather readily, and its eventual removal by the drain water.

These properties of the soil fortunately prevent to a great measure, the accumulation of the more injurious salts added with the application of seepage water, or such as have been stored and become more or less heavily charged with soluble salts.

The water used for direct irrigation, that is, water taken directly from mountain streams does not carry any notable quantity of plant food. Water that has been stored in reservoirs, especially such as receive off-flow, waste and drainage waters, may carry more potash, but with it a very large amount of other salts. These salts are not very intense in their action on vegetation and are disseminated through a very large mass of soil and the most injurious one of them, sodic carbonate, is not retained by the soil. In other words, is rather readily permitted to pass into the ground water and thence into the drain waters, if drains have been established.

The changes effected by the irrigation water after it has entered the soil and before it sinks below the reach of the plants or passes out of the soil, present an interesting subject of study. The general and important question in this connection is, how efficient an agent it is in bringing plant food into an available form. Perhaps an equally important question is, what part does it play in changing deleterious salts into less injurious ones or in removing them from the soil. These questions are much more easily suggested than answered. It is conceded that food to be available to plants must be soluble. It, however, does not necessarily fol-

low that it must be present in the soil in an ordinary aqueous solution. But when present as such it is capable of being taken up by the plants. The most important mineral substances that the plants need are potash, lime, phosphoric acid, chlorin, sulfur etc. The one used in the largest quantity by them is potash. The total quantity of this substance in our average good soil is probably not far from 40 tons to the acre taken to the depth of one foot; the percentage of this available is small and the form in which the available portion is present is doubtful. The rest is present principally as a felspar. It has long been known that the water attacks this mineral and I have shown that the oat plant can obtain potash from it if it has been finely powdered. The question whether the water in the soil dissolves this element of plant food out of the felspar is important. While we can argue that it must do so we want to know that it does, and how fast. We can not always obtain all the information that we desire but we have tried to find out how much potash was present as a free solution in the soil, or better, how much potash was contained in this water after it had entered the soil. An acre-foot of water, as applied to the field, contained almost 12 pounds of potash. A like amount of water as it was found in the soil after irrigation contained 18 pounds, a definite gain of six pounds per acre-foot of water. This is not a large amount of potash to be gathered by this amount of water but it serves to show positively that work is being done by this water, for it is richer by six pounds of potash than it was before. This problem is not so simple as it seems and there is much more involved in it than is here stated. But the fact as here stated is near the truth in spite of the many things that are left out of consideration. There is in it an abundance of chlorids and sulfur as sulfates to supply the plants with these elements.

I have not been able to find that it plays any direct part in supplying the plants with phosphoric acid. These statements show that the water within the soil is an active agent working constantly in behalf of the plants, but there is other work that it does, likewise beneficial to the plant but less directly so.

The water brings potash into solution within the soil but owing to certain properties of the soil particles it is not able to carry it out except in smaller quantities. I have tried to show that the water draining out of the soil carried the sodic carbonate out more readily than it does the sulfate, and I will now add that it seems still more difficult for it to carry out the potash. We have stated that the irrigation water carried 12 pounds potash per acre-foot and the ground water 18 pounds, taking the average of a good many ground waters we get 20 pounds per acre-foot. The drain waters carry only about five pounds per acre foot. The

water then leaves the potash in the soil. I cannot give the ratios between the water applied, the water in the soil and the amount of drainage. It would be much more satisfactory if I could, but we will have to content ourselves with comparing like volumes of water, the acre-foot.

Another question suggests itself. What are these waters doing for us in regard to the salts that we do not want, beside the sodic carbonate which we have seen that they are removing? Their work in this line may be disappointing but still they are efficient and constant friends. We have seen that the water of one of our reservoirs, Terry lake, contained three tons of mineral matter per acre-foot, and we find that an acre-foot of drainage water which came from a pretty bad piece of land, carried July 23, 1900, 2,840 pounds, a little less than half as much as the stored water and very much less than the water within the soil, either after or before irrigation. It is evident that the salts do not pass out of the soil into the drain water as easily as we would expect and yet they carry a large quantity when we calculate it for a year.

The salts that the drain waters carry will vary some with the soil, but in our case we find them much more uniform than the salts carried by the waters while in the ground itself. The salts that we find in these waters are calcic sulfate, magnesic sulfate and the next one in the order of the quantity present is usually sodic carbonate. We have observed one instance in which the quantity of sodic sulfate present was greater than that of the sodic carbonate, but in this neither of these salts were present in large quantities. There was more sodic sulfate present in this sample, and much less sodic carbonate, than is usually found in drain waters.

The salt removed in the largest quantity was found to be calcic sulfate. There is an abundance of this salt in the soil and under our conditions I imagine that it is a matter of indifference whether it is removed or not. The magnesia salts which came next in quantity in the drain waters also occurred abundantly in the soils, especially in those parts of our fields that were in the worst condition. I do not know whether these salts have any part in determining the mechanical condition of the soil or not, it is quite possible that they have, but I am unable to suggest just what that part may be. The presence of magnesic salts in very large quantities in certain ground waters, together with the fact that they are uniformly present, suggest that the series of changes taking place within the soil may end in the elimination of magnesic salts. I thought for a time that we might be able to find still other facts to support this suggestion, perhaps demonstrate that these salts are the last products in the series, but I have not found them and the suggestion seems of doubtful value.

The two most direct services rendered by the drains are, first, the removal of surplus water; second, the elimination of sodic carbonate from the soil. The scope of this bulletin will not permit any further discussion of these subjects, besides we are convinced that the facts are more important than any attempt to explain them would be.

Repeated examinations have failed to show the presence of more than traces of phosphoric acid in the drain and ground waters. This is in marked contrast with the aqueous extracts of some of the soils. The importance of this is that this very valuable, and for our soils particularly desirable substance, is held pretty firmly within the soil, and though the other salts are involved in probably many changes of solution, this substance remains held by the soil particles and is given up under the influence of the plant whose needs it is to supply. How it is held, I do not pretend to say, but we know that it must be retained in some way, for we know that carbonated waters will extract it from the rocks in which it occurs. Phosphoric acid occurs in the soil in which there is both water and carbonic acid, and yet the water within the soil and that which drains out of it carry no more than traces of it.

The exhaustion of the fertility of our soils by the drain waters proceeds then very slowly, so far as the potash and the phosphoric acid is concerned. The former is removed by these means more rapidly than the latter, both in absolute and relative quantities. An acre of good soil taken to a depth of one foot contains about 78,750 pounds of potash and about 9,000 pounds of phosphoric acid. The drain waters contain easily determinable quantities of potash and only traces of phosphoric acid, for the detection of which we have to use large quantities of water or the residues representing it. If we should take a larger quantity of felspar which occurs in these soils, grind and treat it with water and carbonic acid, we could find upon examining the water, after it had been in contact with the felspar for a few days, that it contained easily determinable quantities of phosphoric acid. Why then do the ground and drain waters contain none or only a trace of it? We answer this question by appealing to the observed property of the soil particles in mass to retain certain salts, which we have seen illustrated in a very marked degree in the case of sodic sulfate which we found present in the ground water of the soil in large quantities, but as good as absent or wholly so in the drain waters.

The claim often presented, that we add a significant quantity of fertilizing ingredients with our irrigation waters, cannot be seriously urged for them. Almost the only good they do is in supplying moisture to the plants. Even such waters as have been

stored and have become heavily laden with salts by seepage or solution carry comparatively little of either the potash or nitrogen that is needed by our soils.

Nothing has been said about this latter element, concerning which it is customary to say a great deal. The reason for this is that neither the irrigation, nor ground, nor drain waters showed a content of nitrogen which justified any special notice. There is still another point frequently mentioned in connection with irrigation waters which we will notice a little more fully, i. e., that they fertilize the soil by means of suspended matter which they carry. This point is not in the least applicable to stored waters which remain stored from one to twelve months and sometimes still longer, during which time they would deposit their suspended matter if they ever carried any. This suspended matter tends to silt up the reservoirs which process is evidently proceeding very slowly. The question relative to the value of the suspended matter applies then to water used for direct irrigation and to flood waters. This question, too, is of varying importance according as the streams had in view are mountain streams, whose courses are through massive and metamorphic rocks, as is the case with the upper portions of our rivers, or whether they are plains streams, having their courses through sections of sedimentary material which is easily torn loose by heavy rains and currents. If the section of country through which the rivers run is subject to visitations by torrential rains, the river waters may at such times carry very large amounts of suspended matter. Such conditions do not prevail in this section of Colorado. We occasionally have torrential rains and the river waters may be black or red with mud, according to the character of the country in which the rains fall. But such conditions are of short duration. The period of high water is due to the melting of snow in the high mountains. The water of this season is, it is true, more turbid than during times of low water, times of heavy rain or flood excepted. The amount of suspended matter during this time of high water is insignificant in quantity. I have made observations to establish the amount and found it to be only 0.0016 per cent. of the weight of the water, or about forty-four pounds per acre-foot of water If this sediment were never so rich it would amount to but little as a means of fertilizing our soils. It is no more important from the standpoint of its quality than it is from that of its quantity. It contains just about the same percentage of potash that the soil itself contains and it is even less available if there is any difference at all. The value of this suspended matter is less than I expected to find it.

It is seldom that our waters carry large amounts of suspended matter due to heavy rains, but occasionally they do. On an

occasion when the Poudre river was very high and was carrying limbs, stumps, trunks of trees, etc., I had a sample of its water taken to determine the amount and composition of sediment that it would yield. I found that it yielded 0.213 per cent. of its weight. This was a surprising result for one would have judged it to have held much more matter suspended in it than is here designated. The compositon of this suspended matter was quite as much a matter of surprise, for except in moisture and organic matter it was not very unlike the soil to which it would have been applied if used for irrigation.

The results of these examinations may surprise the reader but I am convinced that the facts are as these examinations show, i. e., that the sediments carried by the waters are small in amount and so similar to the soils in composition that they cannot be considered of such benefit as to make their application a matter to be sought after.

This view was more than sustained by the examination of a silt taken from a reservoir filled with flood water from the Arkansas river, which carried less phosphoric acid, potash, and nitrogen than our average quality of soil contains.

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The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

An Apricot Blight.

—BY—

WENDELL PADDOCK.

PUBLISHED BY THE EXPERIMENT STATION,
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1903.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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PLATE I. Apricot Fruit Attacked by Pear Blight. Photographed June 25.

An Apricot Blight.

By Wendell Paddock.

The writer's attention was called to a disease of apricots in the fall of 1902 by Mr. H. E. Mathews, horticultural inspector of Delta county, which was thought by the growers to be an attack of pear blight. Many of the twigs had blighted and all of the fruit on several of the trees had decayed. At the time of my visit it was too late in the season to see the disease in an active condition, but microscopic examination of the dead twigs and of the dried fruit failed to show any sign of fungous attack. The indications pointed to a bacterial disease but the idea that it was caused by the germs of pear blight was doubted since at that time there was no record of this disease ever having attacked the stone fruits.

The orchard was visited again on June 25, 1903, when the disease was found in an active condition. In one row, containing ten Moorpark and ten Royal apricot trees, every tree was more or less affected, as well as other trees in various parts of the orchard.

At this time many of the fruits were attacked, the diseased areas varying in size from a spot an eighth of an inch in diameter to irregular areas that involved three-fourths of the fruit. The skin over these places soon became nearly black in color and shrunken as the tissues were consumed till the outline of the pit was disclosed. These discolored areas were always definitely outlined and bordered with a zone of watery appearing tissue usually about an eighth of an inch in width. The latter was green in color and as hard as the sound flesh. Three such fruits are shown on Plate I.

The smaller spots where the disease had evidently just started, invariably surrounded a lenticle, thus indicating that the disease gained entrance to the fruit through these openings.

The injury to the twigs may be described best by saying, that they resembled closely, blighting pear or apple twigs. (Plate II.) So far as noticed only tender twigs of the current season's growth were attacked. These were shrivelled and discolored from a few to several inches of their length and small drops of sticky fluid were occasionally found on their surface and upon the

shrivelling leaf-stems. The discolored outer bark blended gradually into normal appearing tissue but the inner bark was discolored for some distance below any external evidence of disease.

Unfortunately the infected orchard is so far from the Experiment Station that the progress of the disease could not be watched, but specimens of diseased ripe fruit were secured from Mr. Mathews on August 2. These were in all stages of decay. Those that were only slightly attacked had a small shrunken area over which the skin was discolored but little. In those specimens where a half or two-thirds of the fruit was involved the tissue was much shrunken and the skin over these areas was quite brown. In some specimens a thick juice, swarming with bacteria, oozed from the diseased tissue and collected in a large drop on the surface. Much watery appearing tissue which was still firm surrounded the diseased parts.

Infection evidently took place more readily early in the season as there was much more diseased fruit at the time of my visit than there was when the later specimens were secured.

Since the appearance of Prof. Jones' paper* in which he proves that pear blight may produce twig blight in various kinds of plum trees it seems probable that this blight and rot of the apricot was due to the same organism. The trees are situated in a mixed orchard and the adjacent pear and apple trees suffered severely from an outbreak of pear blight during the season of 1902, and it was abundant, though not as severe, in 1903. Microscopical examination showed that the diseased parts of both twigs and fruit were swarming with bacteria and that these germs were abundant in the watery appearing though firm flesh of the fruits.

FIG. 1. Apple three days after inoculating with diseased tissue from an apricot fruit.

Working upon this supposition experiments were undertaken as follows: June 30, 12 apples were inoculated by inserting under the skin bits of the watery tissue taken from diseased apricot fruits. These wounds were covered at once with sterile grafting wax. Four of the apples were picked by children but at the end of twelve days the remaining eight were found to have developed the rot that is peculiar to apples attacked by pear blight. The disease gradually spread until the entire apple was discolored and shrivelled and drops of sticky fluid appeared upon the surface of most of them. (Fig. 2.)

*Jones, L. R. Studies Upon Plum Blight. Centralb. f. Parasitenk. u. Infek. II. Abt. II. Band. pp. 835-841.

Nine apple twigs were inoculated on the same day with the fresh diseased tissue from apricot fruits. The disease spread in all of these twigs, killing them from the tips down; in one instance ten inches of the twig from the tip, back, was dead. No difference could be detected in the appearance of these twigs and in those that were known to have been killed by pear blight. Both leaves and twigs shrivelled and turned dark colored and drops of sticky fluid exuded from the bark and from the leaf stems.

On the same day, June 30, seven apple twigs were inoculated with fresh diseased tissue taken from a blighting apple limb. These inoculations were made for the purpose of comparing the disease produced with that produced with germs taken from apricot fruits. All of the twigs developed typical cases of pear blight, becoming shrivelled, dark colored and exuding drops of sticky fluid. The twigs in this lot could not be told from those that had been killed by inoculating with diseased tissue from an apricot fruit. The bacteria appeared to be the same when examined with a microscope and made the same growth when cultivated artifically in the laboratory.

FIG. 2. Apple inoculated with tissue from apricot twig; the latter having been inoculated with a culture of pear blight.

There was no blight in the trees on which these experiments were made and to make sure that the mechanical injury of inoculation could not cause the twigs to die or the fruit to decay, control or check twigs and apples were carried along with all the experiments. These were made by making incisions with a sterile knife through the skin of the apple or through the bark of the twigs; the wounds were then covered with sterilized grafting wax. No disease developed in any of the checks and the injuries soon healed.

These experiments were repeated a number of times with cultures of the bacteria taken from apple twigs, apricot twigs and apricot fruits. Inoculations were made in both apple twigs and fruit and the results were the same, namely, a typical case of pear blight from all three sources.

As there are no apricot trees growing on the College grounds, Mr. J. S. McClelland kindly offered the use of one of his trees for experimental purposes. A number of inoculations were made in the twigs of this tree July 8. Cultures of the disease obtained from apple twigs, apricot twigs and apricot fruit were used. The orchard was visited on July 20 when it was found that blight had been produced in a number of the inoculated twigs, while the check twigs remained sound.

The disease was recovered in pure cultures from these apricot twigs in which blight had been artificially produced and apples inoculated with this material developed typical cases of pear blight. (Fig. 2).

The results of these experiments prove that pear blight may attack apricot twigs and fruit and observations show that the disease may do a considerable amount of damage. While this apricot blight has not yet assumed alarming proportions, yet there is a possibility of its becoming a common disease. It has been found in several Colorado orchards and an apricot disease has been reported from Utah, which is probably due to the same cause. Blighted twigs were also found on Prunus simonii trees which were also thought to be caused by an attack of pear blight.

REMEDIES.

Since this disease has been proven to be due to attacks of pear blight, the logical method of treatment would appear to be the suppression of this disease in apple and pear trees. With pear and apple orchards free from blight there would probably be no apricot blight. There is little probability at present, however, of ever attaining this ideal condition, but much can be done to hold the disease in check if all orchardists will unite in following the best treatment that is now known. This consists in cutting out all blighted limbs after the growing season is over, as in late fall or any time during the winter.

It is now definitely known that the germs of pear blight live over winter in occasional diseased limbs. The germs in such limbs become active in the spring with the growth of the tree and cause a thick fluid to ooze from the diseased bark. This juice is swarming with blight germs and because it is slightly sweet, bees and other insects are frequently attracted to it. That bees do carry blight germs in particles of this sticky juice that may accidently stick to their bodies was proven by Mr. Waite of the Department of Agriculture. Then when visiting flowers in their search for nectar or pollen it is easy to conceive how these particles may become dislodged from the bees' bodies and fall into the nectar in the blossom. Mr. Waite also proved that this does take place as he found pear blight germs growing in nectar in pear flowers. Thus the pear blossoms become sources of infection and the disease spreads rapidly or "like a fire," from which expression the term "fire blight" is derived, as hundreds of insects visit flower after flower.

Just how many of the twigs become infected has not been satisfactorily explained, but in the light of our present knowledge

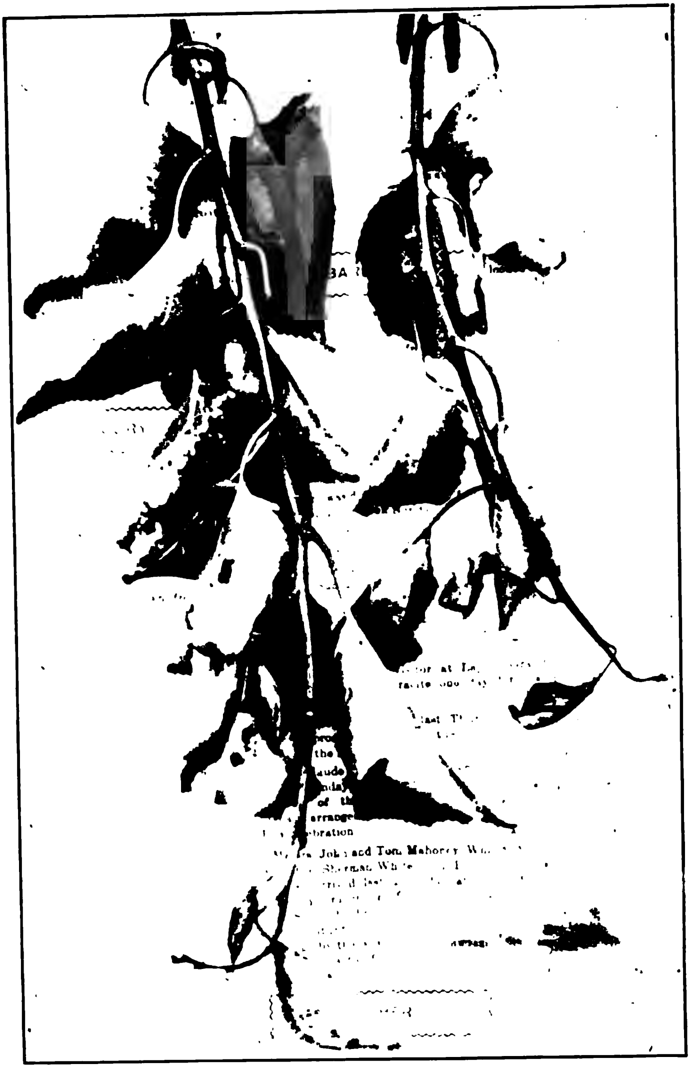

PLATE II. Apricot Twigs Attacked by Pear Blight.
Photographed June 25.

the cases of so-called "hold-over" blight in limbs and twigs must be regarded as the sole means of keeping the disease alive over winter. The appearance of this apricot blight then should emphasize the importance of keeping pear blight in check. All diseased trees whether they be apple, pear, apricot or plum, should be looked over carefully in late fall or during the winter and all blighted limbs and twigs removed. When cutting out diseased branches, especially during the growing season, care should be taken to make the cut 8 or 10 inches below any evidence of discolored bark.

DETAIL OF EXPERIMENTS.

Experiment No. 1. June 30; inoculated 12 apples with diseased tissue from apricot fruits. Apples on the tree and about one-fourth grown. Inoculations made with sterile instruments and diseased tissue taken from in under the skin from the zone of watery appearing tissue. The wounds were covered with sterile grafting wax as soon as the inoculations were made. Notes were taken on the development of the disease as follows:

July 7. Inoculations have taken in four fruits. In one, disease has spread over one-fourth of the surface and a characteristic bead-like drop has formed on the surface. Four fruits destroyed by children. The other four show no signs of disease. July 11. Inoculations have taken in all of the apples.

These apples were eventually entirely consumed by the disease. Five check apples punctured but not inoculated remained sound.

Experiment No. 2. On the same date, June 30, nine apple twigs in the same tree were inoculated with diseased tissue from apricot fruits as described above. All wounds were protected with sterile grafting wax.

July 7. Blight appearing on all of the twigs. Twigs brown and whithering with bead like droplets on surface. July 31, disease has spread 10 inches on one twig and eight inches on another.

Experiment No. 3. For the purpose of comparison seven twigs were inoculated June 30 with diseased tissue from a blighting apple limb. Bits of inner bark which was only slightly discolored by the disease were inserted in incisions made in the tips of green twigs

July 7. Three twigs show no results. Four are diseased and show characteristic symptoms of pear blight, though the disease has not advanced as rapidly as it did in the twigs that were inoculated with tissue from apricot fruits.

July 11. All the twigs in this experiment are now blighting and thick juice has formed in drops on the surface as in the other experiment. The gross appearance of the twigs in the two lots are the same and microscopical examination shows that all diseased parts in both experiments are swarming with bac-

teria which appear identical. Eight check twigs punctured at the tip with a sterile knife show no sign of disease.

Pure cultures of the bacteria from the three sources, apricot fruits, apricot twigs and apple twigs were secured as soon as possible with which further inoculations were made. Plain neutral potato agar was used in making poured plates from which transfers were made to tubes of potato agar, potato plugs and sugar beet plugs. Inoculations were made July 7 with the pure cultures into apple fruits and apple twigs as given in the following tables:

TABLE I.

Inoculations of Apples with Cultures of Bacteria Secured from Diseased Apricot Twigs, Apricot Fruit and Apple Twigs.

No. of Experiment.	No. of Apples.	Sources of Cultures.	Date of Inoculation.	Date of Examination.	Results.
No. 4........	5	Apricot Twigs	July 7	July 28	All discolored and shrivelled.
No. 5........	5	Apricot Fruit	July 7	July 14	Negative.
No. 6	6	Apple Twigs	July 7	July 28	One fruit black and shrivelled.
No. 7	6	Check		July 28	Sound.
No. 8...	6	Apricot Fruit	July 14	July 28	Five fruits shrivelled and discolored.

Evidence of the success of the inoculations became apparent in some instances on the third day. (Fig. 1.) There being no development of disease in any of the apples in Experiment No. 5, further inoculations were undertaken on July 14, as indicated in Experiment No. 8, using another tube of the same culture. Final notes were taken on July 28. The five fruits in Experiment No. 4 inoculated with culture from apricot twigs all discolored and shrivelled. Experiment No. 5 gave negative results, probably due to weak or dead culture material. No. 6, using a culture of known pear blight taken from a blighting apple limb, one fruit black and shrivelled; the other five gave negative results. No. 7, check apples, all sound. No. 8, inoculated with culture from apricot fruit, five apples shrivelled and blackened over most of their surface. One showed no evidence of disease

TABLE II

Inoculation of Apple Twigs with Cultures of Bacteria Secured from Diseased Apricot Twigs, Apricot Fruits and Apple Twigs.

No. of Experiment.	No. of Twigs.	Source of Culture.	Date of Inoculation.	Date of Examination.	Results.
No. 9................................	7	Apricot twigs.	July 7	July 29	Five twigs diseased.
No. 10	7	Apricot fruit.	July 7	July 29	All twigs diseased.
No. 11................................	5	Apple twigs.	July 7	July 29	All twigs diseased.
No. 12	6	Check.		July 29	Sound.

In Experiment No. 9 the disease made good growth in three twigs, extending eight inches in one. The growth was slight in two twigs while the remaining two gave negative results.

The disease made good growth in all of the twigs in Experiment No. 10; one of them being blighted for 18 inches of its length. All twigs blighted in Experiment No. 11. One diseased 18 inches of its length and others for 12 inches. The twigs used in this experiment were younger and more succulent than the others, which no doubt accounts for the greater growth. Check twigs all sound.

There being no apricot trees on the College grounds, Mr. J. S. McClelland kindly offered the use of one of his trees for experimental purposes. Accordingly inoculations were made in the twigs of this tree as shown in Table III. The tree bore no fruit this season.

TABLE III.

Inoculation of Apricot Twigs with Cultures of Bacteria Secured from Diseased Apricot Twigs, Apricot Fruit and Apple Twigs.

No. of Experiment.	No. of Twigs.	Source of Culture.	Date of Inoculation.	Date of Examination.	Results.
No. 13............	7	Apricot twig.	July 8	August 5	Three blighted; four, no results.
No. 14............	5	Apricot fruit.	July 8	August 5	All made some growth.
No. 15............	7	Apple twig.	July 8	August 5	Five blighted; two, no results.
No. 16............	7	Check.		August 5	Sound.

In Experiment No. 13, three twigs of the seven were blighted; one five inches, one eight inches and the third, 10 inches. New growth was selected for the experiments and the inoculations were made as near the tip as possible. The four twigs that gave no results made a rapid growth after inoculation, of from 18 to 20 inches. And curiously enough two of them were blighted at their tips. This can be accounted for by natural infection from the inoculated twigs as four other twigs were found on the tree that were blighted. None of the check twigs showed any evidence of blight and there was none found on the other two trees that stood within 12 feet of the tree experimented on.

All of the twigs in experiment No. 14 were diseased; the blighted areas varying from one to four inches in length.

Cultures of known pear blight were used in Experiment No. 15. Five of seven twigs were blighted, two of them for eight inches from the tip where the inoculations were made.

The disease was recovered in pure form from the inoculated apricot twigs and apples on the tree were inoculated as shown in Table IV. .Specimens of diseased ripe apricots were received at about the this time, together with blighting twigs. Cultures were made from both sources and inoculations were made as is also shown in table IV.

TABLE IV.

Inoculation Experiments with Cultures of Bacteria from Various Sources.

No. of Experiment.	No. of Inoculation.	Source of Culture.	Date of Inoculation.	Date of Examination.	Results.
No. 17.........	6 Apples	Apricot twig.	July 29.	August 18.	Two fruits diseased.
No. 18.........	5 Apples	Ripe apricot fruits.	July 29.	August 18.	All diseased.
No. 19.........	4 Apples	Apricot twigs that had been inoculated with cultures from apricot twigs.	July 29.	August 18.	One fruit diseased.
No. 20..........	6 Apples	Check.		August 18.	Sound.
No. 21.........	10 Apples	Apricot twigs that had been inoculated with cultures of pear blight.	Aug. 7.	August 18.	Three fruits, decaying.
				August 30.	Three more fruits diseased.
No. 22.........	5 Apples	Check.		August 30.	Sound.

Cultures from apricot twigs produced decay in two fruits out of six inoculated while all inoculations with cultures from ripe apricots were successful.

One out of four inoculations was successful, where a culture from an apricot twig, from McClelland's, that had been inoculated with cultures from apricot twigs were used. As a more complete test was desirable than was afforded by No. 19, a similar experiment was undertaken in No. 21. Ten apples were inoculated with diseased tissue taken from an apricot twig that had been inoculated with a known culture of pear blight. Six of these inoculations were successful. The check apples in every instance remained sound.

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The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

Cantaloupe Seed.

— BY —

P. K. BLINN.

PUBLISHED BY THE EXPERIMENT STATION
Fort Collins, Colorado.
1903

Plate I.

Ppate II.

Plate III.

PLATE IV.

CANTALOUPE SEED.

IMPROVEMENT BY SELECTION.

BY PHILO K. BLINN.

The cantaloupe now known as the Rocky Ford was originally Burpee's Netted Gem, but under the favorable conditions which prevail in the arid regions of Colorado, it has developed into a melon surpassing in quality the parent stock, and its superior merits have won for it a new name and a popular reputation.

In the early days of the cantaloupe industry at Rocky Ford, the growers relied on Eastern seedsmen for their supply of seed, and to a certain extent had satisfactory results until the growth of the industry exceeded the supply of reliable seed, when a number of growers were supplied with seed which produced a mixed lot of varieties, wholly unfit for market as Rocky Ford cantaloupes. The loss not only fell heavily on the disappointed grower, but through the agency of bees and other insects carrying the pollen, the injury was easily transmitted to neighboring fields of choice melons, producing crosses of an undesirable nature.

On account of the introduction of these mixed strains, and the varying ideas of seed selection, the Rocky Ford cantaloupe lacks uniformity in many respects ; a large percentage of melons are unmarketable on account of size and form, which renders them unfit to crate. Defective netting and thin, soft flesh are also common imperfections. Because of these defects, the growers sustain a loss that could largely be prevented by planting a better grade of seed.

The cantaloupe is a product of years of systematic selection, and it requires the same methods to maintain its excellence as were employed in its development. Without care in selection, the natural tendency of all cultivated plants to vary will soon cause a good strain of cantaloupes to revert to an undesirable type.

There is a marked contrast between the products of carelessly selected and pedigreed, *i. e.*, carefully selected, melon seed ; the one is inclined to be irregular in size and form, with the netting thin and often wanting, and with a decided tendency to

ripen prematurely, turning yellow and soft; a loss not uncommonly of twenty to forty per cent. in culls, while choice seed produces melons that are uniform in size and shape, the netting thick and complete, the marketable stage more prolonged, and practically no loss in culls.

The wide reputation of the Rocky Ford cantaloupe has created a great demand for Rocky Ford seed, as it is claimed to produce a higher grade of cantaloupes than seed from other States, and each year large quantities are saved to fill this demand, but unfortunately for the industry, the quality of this supply is not what it should be; it is principally produced from the cull piles.

After frost, at the close of the shipping season, everything in the line of a cantaloupe, green or ripe, large or small, is gathered and run through a melon seeder, with no attempt at selection.

This seed is bought by the jobber and seedsman for ten to twenty cents per pound, and when it is on the market it cannot be distinguished from well selected seed, and doubtless is sold as such.

There would be nothing to commend such seed to any practical grower if he realized its source.

As the seed market has been so abused, to procure good seed one must either save it himself, or have seen the melons from which it was saved, or purchase it from a reliable grower before it has passed through several hands.

The fact that seed can be had cheap and growers are willing to plant it, is an evident reason for its existence on the market, but the lack of information as to what constitutes a good seed cantaloupe may also be responsible for poor seed selection. In this bulletin we wish to show what a good melon is and that it pays to plant and save good seed.

STANDARD OF PERFECTION.

The form and outward appearance of a perfect Rocky Ford cantaloupe is well represented in the several plates shown in this bulletin; as to size, it requires a melon slightly over four inches in diameter and about four and five-eighths inches long; it should have silver grey netting that stands out like thick, heavy lace, practically covering the entire melon, save the well-defined slate colored stripes; these should run the whole length of the melon clear cut as if grooved out with a round chisel, and terminating at the blossom end in a small button, well shown in the melon on the left side of Plate III. The interstices in the netting should be light olive green, that turns slightly yellow when the melon is ready for market. A melon with a black skin under the netting is not so attractive in appearance. The proper netting is well brought out in Plate I.

But the outward appearance is not the only basis for selection in saving seed; the inside points are as essential to consider as any external quality, and no one can determine that a melon is fit for seed until it has been cut open and the inside qualities examined; for this reason the machine seeder is of no use in selecting choice seed; the melons should all be cut and examined by hand.

The flesh should be thick and firm, of a smooth texture, and free from watery appearance, rich and melting in flavor. The shipping and keeping qualities depend largely on the solidity of the melon, so the seed cavity should be small and perfectly filled with seed. The color of the flesh near the rind should be dark green, shading lighter toward the seed cavity, which should be salmon or orange in color. The flesh is often mottled with salmon, and not uncommonly the entire flesh is of that color. The flavor is usually quite uniform, though it is sometimes affected by the health of the vines or other conditions of growth.

The seed will bear close inspection, as it is sometimes cracked or sprouted, which renders it of no value for germination.

The first steps in seed selection should be made when the melons are growing. Extra prolific hills should be marked with stakes, and the earliest ripening specimens conforming to the above ideal should be saved as choice seed, and planted in a place isolated from other melons, and the same care should be exercised in the years that follow.

The grower can and should save his own seed, as he can give it more careful attention than any commercial seed grower.

A few growers, realizing the importance of systematic selection, have made the proper choice of seed for their own use.

As an illustration of what can be done in this line, the plates shown in this bulletin represent photographs of melons developed after five years of careful seed selection. Beginning with a melon as nearly perfect as could be found, the old saying that "like produces like" has been exemplified to a marked degree. Each year the number of perfect melons has increased, so that now, when soil, fertility and all growing conditions are favorable, the over-sized melons are eliminated; all melons are completely netted, and practically all are marketable.

Plates II. and IV. represent an average product of the choicest of this seed.

Improvement is still possible, yet the value of careful seed selection has been so demonstrated that if melon growers would adhere to a strict selection of perfect, early-ripening melons, not only would the returns from the melon crop be increased, but the cantaloupe would become a more staple article by virtue of its improved shipping and keeping qualities.

VALUE OF CHOICE SEED.

Unless one has a well developed strain of seed, it is not probable that he can save more than one or two pounds per acre of extra selected seed, so the supply of choice seed is limited.

The market value of the cantaloupe at the time the seed is saved should determine the price of seed. Thus, it requires about as many melons to produce one pound of seed as will fill a standard crate, and actually more, because some melons need to be rejected. This cannot be fully determined until the melon is cut, when, if it proves unfit for seed, it is also lost for market. So the price of seed must be equal to or exceed the price of a crate of melons at the time the seed was saved.

During the first week or ten days of the shipping season at Rocky Ford, it is common to realize from two to six dollars per crate. No one at this time can afford to save seed to sell at the ordinary price per pound. Indeed, few growers are wise enough to save for their own use.

At the average price of cantaloupes through the shipping season, the grower must realize at least a dollar per pound to warrant him in saving seed for the market. At the close of the shipping season, when melons are no longer marketable, the seed is willingly saved for what it will bring. This is the source of a large part of the seed on the market.

The difference in value between seed saved early from perfect melons, of high market worth, and that saved six weeks later, from immature, frost-bitten melons which cannot be marketed, is not often appreciated; yet, if the higher priced seed should yield only one or more crates per acre of early melons, or increase the total yield by several crates, which the extra vitality and superior points of perfection can easily do, the higher priced seed is cheaper at any price, and its value to the melon industry cannot be estimated.

Bulletin 86. **December, 1903**

The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

CROWN GALL.

BY

WENDELL PADDOCK.

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PLATE I.

THE COLORADO EXPERIMENT STATION.

A Department of THE STATE AGRICULTURAL COLLEGE.
For Bulletins address the Director.

CROWN GALL.

By Wendell Paddock.

The subject of crown gall is one of vital importance in Colorado, since under our conditions the organism that is responsible for this disease of fruit trees and plants, finds congenial surroundings for growth and distribution.

The so-called galls are irregular outgrowths of tissue that commonly form around the crown of a tree just below the surface of the ground. They also occur frequently on the roots, but are quite different in appearance from the swellings that are produced by the attacks of woolly aphis, which unfortunately are also very destructive in our State.

The galls increase rapidly in size, when the conditions are favorable, and so interfere with the process of nutrition that the vigor of the tree is greatly impaired. In many instances the death of the tree is but a matter of a few years. The point of attack being underground, the infected trees are commonly unnoticed until they begin to fail. This stage may be recognized by the weak growth and yellow appearance of the foliage.

The pictures in this bulletin give a good idea of the appearance of crown gall. Plate I. shows an extreme case of the disease as affecting a six-year-old plum tree. This tree was undoubtedly attacked in the nursery, and the continued growth of the gall so interfered with its nutrition that it was able to make but a feeble growth and was nearly dead when it was dug. Plate II. is from a photograph of a peach tree, showing a large gall on the roots and a somewhat unusual case of the development of galls on the trunk above ground. Plate III. shows badly diseased apple trees just as they were received from the nursery.

This disease first began to attract the serious attention of Experiment Station workers in 1892, when the California station published a bulletin on the subject. This was followed by a number of articles from different Experiment Stations, but it was not until 1900 that any definite knowledge of the disease was gained. During this year Prof. Toumey, of the Arizona Experiment Station, published a bulletin, in which he proved that crown galls on almond, apricot and peach trees are produced by the irri-

tation of a slime mould, one of the lower forms of fungi. He was able to produce galls at will on young seedlings by inoculating them with bits of the galls, also by planting seedlings in sterile soil and then placing pieces of minced galls about their roots. Under certain conditions minute reproductive bodies are formed on the surface of the galls, which easily work their way through damp soil, or may be carried by irrigation water from tree to tree. Particles of the galls may also be carried by cultivators and other tools, so that it is easy to conceive how the disease may spread from a single infected tree to all the trees in an orchard.

Indications also point to the conclusion that the organism may remain alive for some time in decayed galls, or in galls on dead trees, or on diseased trees that have been removed from the orchard.

It is difficult to estimate the amount of damage that crown gall is responsible for, as it is a disease that is commonly overlooked, and then it is usually several years after infection that the apparent vigor of the tree is affected. Reports from a number of the County Horticultural Inspectors, as well as personal observations, show that crown gall is a common disease in Colorado. It is evident, also, from what has been said, that the effects of the disease will become more apparent as the orchards grow older.

Prof. Toumey has the following to say about the amount of damage that can be attributed to the disease:

> The seriousness of crown gall in various and widely separated portions of the country, is certainly indicative of an enormous annual loss to the fruit industry. In estimating the amount of damage done by crown gall, consideration must be given to the fact that it usually occurs underground, and is rarely seen except when the trees are taken from the nursery, or when excavations are made at the crowns. The majority of diseased trees live on year after year, but make less growth and in all probability produce less and poorer fruit than healthy trees. It is not sufficient for a tree to simply live. It must grow and ruit abundantly to be profitable. The total annual loss from this disease in this country in all probability reaches the enormous sum of from $500,000 to $1,000,000, possibly much more.

Crown gall is found on a variety of plants, including almond, apple, apricot, blackberry, cherry, chestnut, English walnut, grape, peach, pear, plum, poplar and raspberry. In the experiments above mentioned, it was found that the disease could be transferred readily from the almond to apricot and peach trees, thus indicating that the same organism is responsible for crown gall on these three hosts. Serious investigation of the galls on the other trees and plants have not yet been undertaken, but it is likely that the disease is of the same nature, if not induced by the same organism. It is to be hoped that this point may soon be established, as it is important to know, for instance, whether diseased raspberry and blackberry bushes, when planted in an orchard, may not be the means of infecting the trees, or, in the

case of a mixed orchard, the disease may not spread from stone fruits to apples and pears, or *vice versa*.

The disease does not seem to be so destructive in most sections where irrigation is not practiced, consequently many nurserymen give it no attention, or are entirely ignorant of the subject. That crown gall is abundant in such nursery districts is proven by the fact that but few shipments of nursery stock are ever received from points outside of the State that are entirely free from the disease. One County Horticultural Inspector destroyed two car-loads of trees in one season, largely because they were infected with crown gall. Most of our inspectors are equally rigid in their examinations, but it is impossible to detect all diseased trees, especially where the disease has just started.

Prof. Toumey goes so far as to say:

> Every tree that comes from an infested nursery is dangerous, and when such trees are planted, great chances are taken.

And again:

> If bundles of trees are received having a few with galls upon them, it is not safe to simply throw out the visibly diseased ones. There is no reason why the remainder of the bundle should not have the infection upon them from contact with diseased trees, and the whole should be destroyed.

The following extract from Bulletin No. 191 of the State Experiment Station of New York, may be taken as representing the general attitude of nurserymen toward the disease:

> We find crown gall not uncommon in the nurseries in western New York, but we know of no case where it has caused material loss. * * * Usually nurserymen discard the worst affected trees.

So long as the disease is not serious in their own locality, the nurserymen see no reason why they should go to the expense and trouble necessary to eradicate it, consequently the disease has spread, gradually, until it is quite common in many of the nursery districts.

The Experiment Station occasionally receives letters from nurserymen protesting against the destruction of their stock. One firm thought that fraud was being practiced when their trees were rejected, as they had never heard of this disease. Another nurseryman sent 100 high priced trees to the Experiment Station which were all condemned by the Inspector. This gentleman claimed that the galls, many of which were as large as one's fist (Plate III.), were due to a characteristic varietal growth, and not to a disease.

The best remedy for most plant diseases is preventative rather than curative, therefore the best line of treatment for crown gall would be, first of all, to buy nursery stock from nurseries that are known to be free from the disease. And in this connection it is a pleasure to state that, so far as is now known, all the nurseries of this State are free from crown gall.

PLATE II.

It will not do to try to remove the galls before the tree is planted, as it is likely that with the greatest care some of the organism will remain. In that case the disease has been introduced into the orchard, and the infection of the healthy trees is only a question of time. The majority of trees that are infected in the nursery, when planted in Colorado, make an unsatisfactory growth, and probably but few of them ever live to produce paying crops.

The disease does not appear to be so destructive to older trees, but nevertheless its effects are severe. Some experiments conducted in Arizona indicate that in such cases the disease may be held in check in a measure. The mode of treatment consists in examining the trees every season and cutting away all traces of galls from about the crowns. The wounds are then thoroughly covered with a paste made after the following formula:

Copper sulphate (bluestone), two parts.
Iron sulphate (copperas), one part.
Lime (unslaked), three parts.

The three ingredients are reduced to a fine powder then mixed thoroughly, after which enough water is added to make a thick paste.

All diseased wood should be collected and burned.

The important point, then, in controlling crown gall would seem to be to keep the disease out of the orchards, and in order to do this it is necessary to secure nursery stock that is free from the infection. All possible assistance should be given the County Inspectors in their inspection of nursery stock. In counties where many trees are being planted, sufficient assistance should be provided, so that there will be no possibility of any shipments being overlooked. And, finally, some means should be devised whereby the importance of inspection can be impressed on the growers, since, in some instances, they antagonize the inspectors and hinder their work. It is no doubt true, that the inspection of nursery stock alone, if well done, pays many times over for all the expense incurred, even in those counties which expend the most money in orchard inspection.

PLATE III.

Press Bulletin No. 16. Feb., 1903.

The Agricultural Experiment Station

FORT COLLINS, COLORADO.

THE PRAIRIE DOG AS A RANGE PEST

AND

METHODS OF EXTERMINATION.

BY J. E. PAYNE.

Probably the lowest estimate we can reasonably make is that two per cent. of the land in Eastern Colorado is occupied by prairie dog towns. Most persons would put the amount at ten per cent. This would equal 412 square miles. In some counties fully ten per cent. of the land is used by the dogs. To estimate the loss to the state by the existence of these pests, we must consider how many steers the range occupied by them would support. The average square mile will keep twenty head of steers ; but the average square mile of dog town will not support more than five steers. This makes a net loss, in carrying capacity, of fifteen steers per square mile caused by the presence of the prairie dogs. So, the 412 square miles would support 6,000 steers. These, at three years old, are worth $150,000, making an annual loss of $50,000 at this estimate. But, as the country becomes more thickly settled, the dogs increase more rapidly than they do on the open range, far from settlements.

Increase.—Female prairie dogs seem to bear from four to eight young at a birth. This rate would tend to double the dog population yearly. If the number did double annually, the whole territory would be fully occupied by them in six years. But it is only where the presence of man protects them from their natural enemies—the hawks, snakes and badgers—that they really do increase so rapidly. We feel the necessity for destroying the rattle snakes; but the bull snake should be encouraged, as he is ordinarily a harmless ally of man in the fight against prairie dogs. One well-grown bull snake will probably destroy the increase of at least ten pairs of prairie dogs.

Means of Extermination.—When man has, from necessity, ignorance or choice, destroyed the natural enemies of the prairie dogs, he must rely upon other means to hold the dogs in check. A few of these are suggested below:

Carbon Bi-Sulphide Treatment.—Carbon bi-sulphide is a colorless liquid which quickly changes to a very heavy, poisonous gas. It is used by pouring the liquid on some absorbent material, as balls of rags, cotton, or horse-dung balls. and placing the saturated material in the burrows. About one tablespoonful is enough for an average burrow. The burrow is then packed full of earth to prevent the dogs digging out. This remedy is most economically used by using it to finish those dogs which have failed to take the poison which usually destroys most of the dogs in a town. Carbon bi-sulphide has failed in places where the soil is very porous, as the gas goes into the surrounding soil so quickly that the air in the burrow is not sufficiently poisoned to kill. It also fails when not enough liquid is used to fill the burrow with gas, as the gas goes to the bottom, leaving the upper air free from poison. This remedy can be used at any time of the year.

Poisoning.—This is one of the most common methods of extermination. Poisoned grain is used in winter, and poisoned fruit or vegetables in summer. Strychnine is the safest poison for general use, and usually the surest. Dissolve two ounces of strychnine sulphate in warm water, and add one quart of molasses. Thoroughly mix this with one bushel of wheat. After all the liquid is absorbed, add enough corn meal to prevent the grain sticking together. Put about one tablespoonful of the piosoned grain about each hole, putting it at three or four places, so as to avoid, as far as possible, attracting cattle which may be passing through the dog town. Kansas uses a mixture containing cyanide of potassium and strychnine, and some minor ingredients put in to make the dose more palatable. The cyanide of potassium soon evaporates and becomes useless. The advice given by the field agent in Kansas is to put the poison out just after a storm in winter, when all the dogs are hungry. Strychnine put into pieces of potatoes may be used in summer; this has been used quite successfully on a small scale.

Introducing Contagious Diseases.—This is a remedy which has been used occasionally with success. There are some companies who make virus for inoculating animals with contagious diseases. Great results are claimed for this method. But it may be best to confine such work to methods which we can control.

Work in Kansas.—In 1901, the Legislature of Kansas appropriated $5,000 for work aiding the extermination of prairie dogs. An agent was appointed to manage the investigation. He tested several remedies, and finally decided that poisoning with a mixture containing strychnine was the most economical. He bought material at wholesale rates, prepared the poison, and furnished it to users at cost. During the first year he distributed 3,300 cans, which is enough to poison grain for the treatment of 132,000 acres.

The Kansas law authorizes township trustees to hire men to work at exterminating prairie dogs. A great many townships in which large tracts of unoccupied lands were located availed themselves of this privilege.

The Problem in Colorado.—In Eastern Colorado, even if each man living in the country should kill all the dogs on his land, only a small proportion would be destroyed, as nearly all the land is owned by either the Government or by non-residents. As men cannot afford to spend much money on land over which they have no control, the prairie dogs on neighboring land would soon overrun them after they had destroyed those on their own land.

The only way by which prairie dogs in Eastern Colorado can be exterminated is by the working of a state law authorizing counties to spend money in exterminating the dogs located upon the land of non-resident owners and upon Government land.

If there is sufficient demand, some one may take up the manufacture of the poison as a business. The greater the demand for the poison, the cheaper it could be furnished. The Kansas Experiment Station has recently been compelled to advance the price of the poison it prepares, on account of an advance in the price of strychnine.

Press Bulletin No. 17. Feb., 1903.

The Agricultural Experiment Station

FORT COLLINS, COLORADO.

TRIALS OF

MACARONI WHEAT BY DRY FARMING.

1902.

BY J. E. PAYNE.

Early in March, 1902, the Experiment Station was enabled by the help given by the cerealist of the Bureau of Plant Industry of the Department of Agriculture to distribute seed of macaroni wheat to a number of carefully chosen correspondents who were in position to give the wheat a fair trial in comparison with other wheat.

The wheat was all grown without irrigation and in every case received ordinary field treatment. Each person was furnished enough seed to plant two acres. Some planted more by planting thinner.

Three varieties were sent out. These being Black Don, Yellow Gharnovka and Kubanka. So far as we knew the soils, the varieties were distributed so that they would be tested upon soil somewhat similar to the soil upon which they grew in Russia.

Of the eleven plats planted, one was entirely destroyed by hail when it was giving great promise of a large crop. Two neighborhoods to which it was distributed experienced extremely droughty conditions and produced very little grain of any kind.

Each party who raised wheat from the seed furnished by us sent a sample. These samples compared quite favorably with the original seed which was grown in Russia.

When we visited the men who raised the wheat last summer, they all expressed satisfaction with the wheat and were willing to plant it extensively if they were sure they could sell their wheat when raised. Nearly all of them found that they had planted it too thinly, as it did not stool, or tiller, like ordinary wheat; but threw up only from one to three stalks from each seed planted.

The following statements are taken from the reports sent us by the parties whose names accompany them. The reports were

made in the form of answers to questions. Here they are put into the form of statements:

J. L. Parker, who lives on Sec. 15, T. 1 N., R. 51 W., Akron, Colo., says:

I planted three and one fourth acres to macaroni wheat of the variety called Black Don on black loam soil late in March. Planted forty pounds per acre, and got rather a thin stand. The season was very dry, only light showers falling until the wheat was heading out. The wheat ripened by July 15th, which was a little later than other wheat in the vicinity. The yield was 15 bushels per acre, while other wheat made 5 to 7 bushels under the same conditions.

The only fault I can find with it is that it bears such long beards.

J. A. Kimber, who lives on Sec. 33, T. 1 N., R. 43 W., Wray, Colo., says:

I sowed two acres of macaroni wheat of the variety called Black Don on sandy loam land March 15th, at the rate of sixty pounds per acre. The season was favorable, except from the 10th to the 20th of June, when the weather was very dry. The wheat was several days later than varieties usually grown here. It was cut July 21st, and made 10 bushels per acre. The seed raised was more shrunken than other varieties grown near. Am inclined to believe that this wheat is too late a variety for this part of the country. The long beards probably furnish considerable protection from hail.

A. C. Cauble, who lives on Sec. 32, T. 7 N., R. 43 W., Holyoke, Colo., reports as follows:

I planted two and one half acres to macaroni wheat, using the variety known as Yellow Gharnovka. Planted it March 28th on black sandy loam soil, at the rate of fifty pounds per acre. Got a poor stand. Hail cut the wheat off once early in the season. It was ripe July 20th and yielded 10 bushels per acre of wheat about equal in quality to ordinary wheat which made 13½ bushels. It is earlier than the other wheat grown here. I believe it is a good wheat for this country if we had a market for it. The straw is not good for forage.

A. F. Lindon, Sec. 32, T. 7 N., R. 47 W., Holyoke, Colo., reports as follows:

I planted three acres to Yellow Gharnovka macaroni wheat March 12th. The stand was poor. Grasshoppers damaged it badly, and Russian thistles also did much damage. The wheat is a little earlier than other wheat grown here. It ripened July 15th. Threshed 2 bushels from three acres. My other wheat I did not thresh, but it would make from ½ to 2 bushels per acre. The macaroni wheat was good quality.

J. F. Bandy, Sec. 9, T. 8 S., R. 49 W., Seibert, Colo., says:

I planted two acres to macaroni wheat on black sandy soil March 1st. Seeded at the rate of one bushel per acre. The stand was very poor. The season was very dry and the crop was damaged some by hail. This wheat yielded 2 bushels per acre, while other wheat was a complete failure. The variety sown was Yellow Gharnovka. It is earlier than other varieties in use here.

E. E. T. Hazen, Sec. 6, T. 6 N., R. 43 W., Holyoke, Colo., says:

April 8th I sowed two acres of sandy loam land to Yellow Gharnovka macaroni wheat, at the rate of one bushel per acre. Got a poor stand. May 25th hail cut it to ground. Sand storms also damaged it, and grasshoppers also damaged it. It ripened July 20th, yielding 10.5 bushels per acre of extra quality grain. It did not stool much. It ripened about the same time as other wheat here.

J. A. Reidesel, Sec. 5, T. 5 S., R. 45 W., Idalia, Colo., says:

March 18th I sowed three acres of Kubanka macaroni wheat on brown sandy loam land, using forty pounds of seed per acre. July 22d, it was har-

vested, yielding 15 bushels per acre of wheat of good quality. It was damaged fully 10 per cent. by grasshoppers. It ripened at same time my other wheat ripened. It does not stool like other wheat, and requires more seed per acre. Other wheat yielded 12 bushels per acre this year.

Henry Moellenburg, Sec. 23, T. 4 S., R. 44 W., Idalia, Colo., says:

Planted three and one half acres to Kubanka macaroni wheat on dark clay land, at the rate of thirty eight pounds per acre, March 16th. Cut July 16th, yielding 12 bushels per acre. Some damaged by grasshoppers. Better quality than other wheat and ripened same time. Stand thin. Other wheat in field made 18 bushels per acre. Not any faults. I would like to try it again.

H. F. Myers, Sec. 6, T. 1 S., R. 44 W., Vernon, Colo., says:

March 19th I planted five acres to Kubanka macaroni wheat on light prairie loam soil. Planted at the rate of forty-five pounds per acre. July 25th, it was ripe. It yielded 10¾ bushels per acre, which was about the same that other wheat yielded under the same conditions. The grain was of good quality. The stand was poor because this wheat stooled so little. I would sow about one and one half bushels per acre to get a full stand of this variety. It is later than wheat usually grown here. I noticed that when severe drought came, the extra stalks on this wheat dried up, while the main stalk continued to grow.

A. S. Kester, Sec. 33, T. 3 S., R. 43 W., Lansing, Colo., says:

I planted two acres of Kubanka macaroni wheat on black loam soil March 12th, at the rate of one bushel per acre. Got a good stand. The season was an average one. The wheat was harvested July 17th, making 17 bushels per acre of good quality. It was damaged 10 per cent. by grasshoppers. It ripened about the same time my other wheat did. The other wheat made 15 bushels per acre. I believe it is a good kind of wheat. The straw is inclined to be soft and will be damaged by grasshoppers

CONCLUSIONS.

Damage from hail, drought and insect pests was about the average from such causes.

Late ripening of the varieties tested is a serious fault. The yield of macaroni wheat was nearly the same as the common wheat, except under extremely unfavorable conditions, when some evidence shows it to be surer to make a crop than the common varieties.

Nearly all sowed the wheat too thinly. This probably reduced its yield.

One year's trial is not enough to prove the worth of any grain. When large fields of it are grown during a period of several years, we can then speak positively. But, it now seems worthy of continued trials; and during this time, an effort should be made to improve it in the matter of early maturity.

Press Bulletin No. 18. Feb., 1903.

The Agricultural Experiment Station

FORT COLLINS, COLORADO.

CROPS FOR UNIRRIGATED LANDS.

BY J. E. PAYNE.

After seven years of experience in Eastern Colorado we feel justified in making some recommendations for the use of those who may try crop raising there without irrigation.

Soils. We have never seen any good crops grown without irrigation upon adobe or very heavy clay soils. But upon sandy loam, sandy and medium and light clay soils, we have seen crops raised on a paying basis nearly every year when given especial attention.

Seeding and Culture. The natural vegetation of the country shows that thin seeding is necessary. The buffalo grasses are thin where they do not get the use of the rain which falls, and thick in locations which catch extra water, as in low lands partly surrounded by hills. All crops should be planted thinly, so that they will not need too much water to make the growth high enough to harvest. All crops should be thoroughly cultivated, so as to give them the benefit of the largest per cent. of the rainfall. Thorough and clean culture should be pursued until August 1st, whether rain falls or not, as the crop is thus kept in good condition to use the rains which fall late in the season; while if the crops are not kept clean, no amount of cultivation after the late rains will take the place of the cultivation which should have been given before. The most important thing—next to water—is doing the work at the proper time.

Ground intended for planting in May should be thoroughly disced in March or early in April so as to hold the early moisture.

These remarks refer only to crops which are recommended in this bulletin, and to crops usually planted in rows and cultivated.

Crops to Depend Upon. Eastern Colorado is mainly a stock country, and the needs of the country demand rough forage for wintering stock.

We have found that the sorghums and a few acclimated varieties of corn produce paying crops, taking an average of five year's crops as a basis for estimates. Very few of the sorghums ripen seed in Northeastern Colorado, so if one wishes to produce seed of either *corn* or *sorghum*, he should be careful to plant seed which was grown in the vicinity.

The following table gives the most important facts concerning the varieties best known.

NAME.	SWEET OR NON-SACCHARINE.	PRODUCES SEED.	FODDER.	
			QUALITY.	QUANTITY.
Early Amber	Sweet	Abundantly	Good	Large
Early Orange	"	Sparingly	"	"
Kansas Orange	"	"	"	"
Colman	"	"	"	Medium
Collier	"	"	"	"
Folger's Early	"	"	"	"
Red Kafir Corn	Non-Sac.	"	"	"
White Kafir Corn	"	"	"	"
Jerusalem	"	Abundantly	Poor	Small
Yellow Milo Maize	"	Sparingly	Good	Medium
White Milo Maize	"	"	"	"
Brown Durra	"	Abundantly	Poor	Small

Broom Corn. Broom corn is usually easily raised. The market price of good brush makes its production profitable or unprofitable and not the amount which can be produced. The fodder and corn always have a ready home market, but broom corn must be sent out of the country.

Mexican Corn. A flint variety grown in Northern Lincoln, Western Kit Carson, and Central Arapahoe counties. Very rich in protein. Produces good fodder and nearly always some corn. Some years the ears merely stick out of the ground and the tassels may not be more than two feet high.

There are several other varieties of corn which do well, but they are confined to small neighborhoods and we cannot be sure that much seed could be had.

Planting. Planting should be done with a lister drill. Use from two to five pounds of seed per acre—according to quality of seed.

Cultivation. This should be done as long as possible with the harrow. Then follow with the weeder, and if it seems best, with the cultivator. *Careful* and *thorough* culture must be given. If planted on sod, it may be planted with special planter drill. If planted on land broken years ago and left unused during recent years, it will not be likely to produce a good crop unless the season is very favorable.

Time of Planting. May 1st to June 10th, according to the conditions. Sorghum does not grow much until warm weather, but it should be planted while the early moisture is in the ground.

With up-to-date tools and plenty of horses one man can plant and cultivate 160 acres in corn or sorghum. He must use gang listers, large harrows and gang weeders in order to do this, but by working in this way the cost of producing feed may be reduced considerably.

The sorghums are as sure to make a paying crop in Eastern Colorado as corn is in Eastern Kansas.

It is the hope of the author that he can help the people to make two steers grow in Eastern Colorado "where one grew before."

Press Bulletin No. 19. April, 1903.

The Agricultural Experiment Station

FORT COLLINS, COLORADO.

GRASSHOPPERS.

THEIR HABITS AND REMEDIES.

BY C. P. GILLETTE.

The several injurious species of grasshoppers occurring in Colorado undoubtedly occasion heavier annual lôss than any other single insect pest, not excepting the codlin moth. It is the object of this brief paper to give the most important information as to the habits of these destructive insects and the remedies that may be used against them.

LIFE HABITS.

All our specially destructive grasshoppers spend the winter in the egg state in the ground. The eggs are from about 3 to 4-sixteenths of an inch in length, cylindrical in form, yellowish white to yellowish brown in color and are deposited in compact masses of from about 20 to as many as 75 together. The females dig small holes to the depth of an inch or a little more with the stout ovipositor at the tip of the abdomen. The abdomen is then thrust in as far as it will reach and a gluey material is exuded and smeared over the inner wall of the little cavity making it firm. Then the egg mass is deposited and it is also covered with the gluey material which soon hardens and protects the eggs from excessive moisture and from being easily crushed. Egg-laying of some of the species begins about the first of August and continues until hard freezing late in the fall kills all the old females. As a rule, a single female deposits two packets of eggs.

The places most chosen by the females for the purpose of egg-laying are ditch-banks, the borders of fields and road

sides. The egg packets are also most often found about the roots of plants, as alfalfa, clover or weeds. If the eggs are at all abundant, a little digging about such plants where

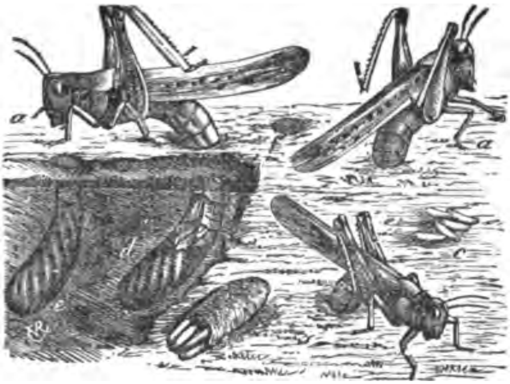

FIG. 1.—GRASSHOPPERS LAYING EGGS.—After Riley.

the grasshoppers were numerous in the fall will usually reveal them.

The eggs begin to hatch about as soon as vegetation starts in the spring and continue for several weeks, but the eggs of a single pod all hatch together. The young hoppers begin at once to feed upon such tender growing plants as are at hand various common weeds entering largely into their diet. When young and wingless, they are inclined to remain rather close to their place of hatching but as they grow they scatter about more and may become quite evenly distributed through a large field. The tendency to remain together in large flocks is more or less marked however, and particularly is this noticed late in the afternoon when they congregate along the borders of the fields and upon the fences to spend the night. So marked is this habit that where grasshoppers are abundant it is a common sight to see a strip from ten to thirty or more feet wide about the borders of an alfalfa field that is almost denuded of vegetation. Sometimes the grasshoppers do great damage by ascending trees and eating fruit and foliage and gnawing the tender bark from the twigs. Such injuries usually occur alongside an alfalfa or pasture field from which the grasshoppers have migrated.

REMEDIES.

There are many remedies that may be used to advantage against grasshoppers. Which is best to use in a given case depends upon circumstances. It may be best often to use a combination of remedial or preventive measures.

DESTRUCTION OF THE EGGS.

The best of all artificial remedies, where it can be used, is plowing deeply late in the fall or early in the spring, all the ground where the eggs are abundant. Even the young hoppers, when very small, may be turned under quite successfully in this manner and destroyed.

Where plowing cannot be resorted to, a thorough harrowing, especially with a disk harrow, will do much to destroy the eggs. Some will be crushed, others will be eaten by birds and still others will succumb to the freezing and thawing and drying when separated from the egg-mass. These remedies must be applied before the young hoppers hatch.

DESTRUCTION OF THE GRASSHOPPERS.

Burning.—When the grasshoppers are quite small and travel slowly, they may be killed along ditch banks and in other places where they are abundant by covering the ground with straw and then burning it.

Poisoning.—Young hoppers may also be poisoned in large numbers by thoroughly spraying the young weeds and other vegetation on the waste land where they are hatching in large numbers with any of the arsenical poisons, as Paris green, arsenite of lime, arsenate of lead, etc. The poisons should be used rather strong. Later, when the hoppers get into the crops, they may be poisoned quite successfully by the use of arsenic-bran mash. Mix a pound of Paris green or white arsenic with about 20 pounds of bran, moisten enough with water so that the particles will adhere together in a crumbly mass, and then sow broadcast where the hoppers are most abundant. Do not use this where chickens feed.

Bandages.—To keep grasshoppers out of trees, bandage the trunks with cotton batting or printer's ink or axle grease. If either of the last two named substances is used do not put it upon the bark of the tree but upon heavy paper which is first wrapped about the trunk. If the hoppers jump or fly into the trees, using poisonous sprays or driving with whips will have to be resorted to.

Hopper-dozers.—For open fields, the hopper-dozers, or catchers, are probably our best remedy after the grasshoppers have hatched. A cheap and simple form of hopper-dozer, which is probably as effectual as any, is shown at Fig. 2. The pan is made of sheet iron and the back is extended by means of upright stakes and a strip of muslin. In the pan is placed a quantity of kerosene or crude petro-

leum, or a small amount of water with oil upon the surface and the pan or dozer is then drawn over the field by hand or by means of a couple of horses kept well apart so as to collect the hoppers. If the horses are in front of the middle of the pan, many of the hoppers will jump out at the

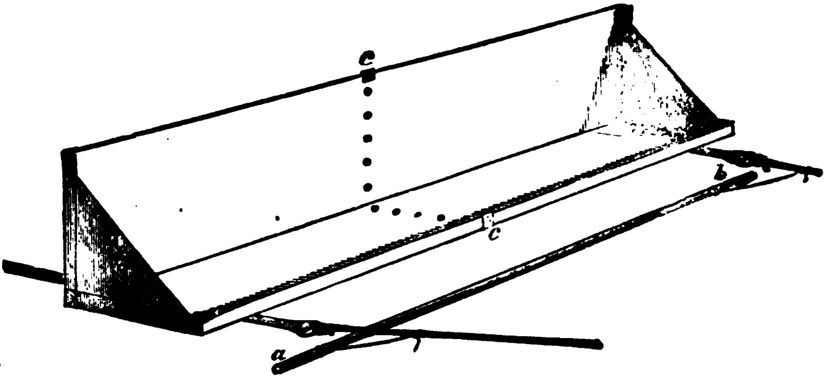

FIG. 2.—HOPPER-DOZERS.—After Riley.

sides and escape the pan. Every hopper that gets wet with the oil dies. Many will jump into the oil and jump out to die. When they become abundant in the pan, they should be thrown out.

Another type of hopper-dozer which is much liked by many who have used it catches the grasshoppers alive in a box. It is manufactured by a Mr. J. H. Behrens, Evans, Colorado, and costs about $12.00.

Grasshopper Diseases.—The African grasshopper fungus was experimented with quite extensively last summer in Colorado. nearly 400 tubes of the fungus being sent out to those requesting a quantity for trial. The station also used a number of tubes endeavoring to spread the disease among the grasshoppers about Fort Collins. There is very little evidence that the disease became destructive to the grasshoppers in any case where it was used. There is a native grasshopper disease that is generally distributed over the country which did kill great numbers of grasshoppers in nearly all parts of the state last year. It is a peculiarity of this disease that it causes its victims to crawl to the tops of plants to die. If this disease does not occur in a locality where grasshoppers are abundant, it might be well to obtain a quantity of the dead hoppers from this disease, crush them as finely as possible in water and sprinkle the decoction over the living hoppers and food-plants where possible, especially upon low ground, and just before dark.

Press Bulletin No. 20. August, 1903.

The Agricultural Experiment Station

FORT COLLINS, COLORADO.

PLANT LICE AND THEIR REMEDIES.

BY S. ARTHUR JOHNSON.

The abundance of plant lice during the past three years has led to a number of experiments at the Station which have covered a wide range of insects and insecticides. The results indicate that proper methods will keep these pests under control.

LIFE HISTORY.

Plant lice are tiny insects usually rounded in form and provided with two little tubes which extend upward and backward from the abdomen. Lice live upon the juices of plants by thrusting their bills through the epidermis of the tender twigs or leaves. The first brood in the spring is produced from eggs which were laid the previous fall. The other generations, except the last, are females born alive, and as these young begin immediately to suck juices and soon bear other young, the number which may result in a single season from the hatching of one egg is almost incredible. The first generations are wingless and live not far from the place where the eggs hatched. In time, however, winged individuals appear. These fly to new feeding grounds and are the chief source of distribution. Most lice are green and escape notice, but some are made conspicuous by their colors. The last brood in the fall lay eggs. These may be seen after the leaves have fallen as tiny black oblong objects on the limbs and about the buds. An abundance of these indicates that watchfulness will be needed the following spring.

THEIR ENEMIES.

Generally plant lice are kept under control by their enemies, chief of which are the lady-birds and syrphus flies. Adult lady-birds may usually be recognized as oval red beetles spotted with black. The larvae are oblong, rough and commonly mottled red and black. They have three pairs of legs and a distinct head.

The eggs are yellow and laid in patches where lice are abundant. The syrphus fly larvae are smooth, green or greenish white and without distinct legs and head. The eggs are white, oblong bodies which are laid singly on the leaves of infested plants. Where the enemies are abundant they will destroy the lice and spraying is unnecessary.

INSECTICIDES.

From the manner of their feeding it is impossible to kill plant lice with poisons. It is necessary to employ some substance which will kill by contact and to apply it very thoroughly, for every insect which escapes the application remains to repopulate the food plant. These precautions are valuable: 1. Spray upward with force so as to wet the under side of the leaves. 2. Spray before the winged forms appear to prevent distribution. Among the best insecticides are:

Whale-oil Soap. This must be dissolved in boiling water, after which it is diluted in the proportion of one pound of soap to from six to twelve gallons of water.

Tobacco Stem Decoction. Tobacco stems or dust may be purchased from cigar manufacturers at a very reasonable price. They should be put in cold water, heated to boiling point and boiled for half or three-quarters of an hour. The decoction is then diluted to make from two to five gallons of spray for each pound of stems. The preparation should be used before it becomes sour or stale.

Kerosene Emulsion. This may be used in proportion of from one gallon of oil to fifteen of water, to one to twenty-five.

Whale-oil soap and kerosene emulsion are liable to injure the foliage when used in strong solutions. Probably the tobacco preparations are safest where these are needed.

COMMON PLANT LICE.

Green Apple Louse. This is rather difficult to kill. It may be treated with whale-oil soap in the proportion of one pound of soap to six gallons of water; tobacco stem decoction, one pound to three gallons; or kerosene emulsion, one to fifteen. It is best to spray before the lice have caused the leaves to roll or early in the spring when the lice have just hatched.

Green Plum Louse. Use tobacco stem decoction, one pound to four gallons, or tobacco soap, one pound to twelve gallons.

Black Cherry Louse. Is conspicuous for its color. It is rather hard to kill. Apply the stronger strengths of any of the insecticides named above.

Snowball Louse. Lives in the young buds and curls the leaves in such a way that it cannot be easily reached. Drench the stems and opening buds in the spring with whale-oil soap, one pound to eight gallons.

Bulletins 87-90. June, 1904.

The Agricultural Experiment Station

OF THE

Colorado Agricultural College.

THE PLAINS OF COLORADO

Bulletins by J. E. Payne.

87. CATTLE RAISING ON THE PLAINS.
88. DAIRYING ON THE PLAINS.
89. WHEAT RAISING ON THE PLAINS.
90. UNIRRIGATED ALFALFA ON UPLAND.

PUBLISHED BY THE EXPERIMENT STATION
Fort Collins, Colorado.
1904.

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FORT COLLINS, COLORADO.

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INTRODUCTORY.

BY THE DIRECTOR.

These particular bulletins, as well as several already issued, are a contribution from the studies made by the Experiment Stations on the Great Plains of Colorado.

When the agriculture of the state is under consideration, attention is usually confined to the irrigated area of the state and the plains are not considered. It has more commonly been thought that the plains were material for future development rather than of present importance. It has, however, been felt by the more careful observers that they were agriculturally of considerable importance, and that their extent is so large that the product from any given area does not need to be large to make the aggregate worth consideration. The plains of Colorado are limited on the West by the foot-hills of the mountains and on the East they extend to the state line, hence their extent East and West is two hundred miles, and North and South the whole width of the state. There is thus an area of forty thousand square miles, forming the Plains in Colorado.

Irrigation is confined to a limited region near the mountains and tongues of land extending along the Platte and Arkansas rivers. The area under irrigation east of the mountains is less than four thousand square miles. Almost every foot of the Plains is intrinsically as productive as the areas under irrigation, provided it could be supplied with water. This condition has been so evident that there have been many dreams that the whole area of the Plains would be irrigated in the future, not realizing that such a hope is an impossibility from the failure of the water supply, hence the Plains must substantially remain as plains, and their development must recognize the limitations of climate and of water, taking advantage of every favorable feature, and based on conditions as they are.

The settlers who came with the expectation of growing the same crops and using the same methods as in a humid country, instead of adapting themselves to the conditions, were doomed to

failure and gave a bad name to the Plains. With fuller understanding, a more just appreciation of the capabilities is being obtained.

In 1893 the Legislature caused a branch Station to be started near Cheyenne Wells. The trials for the first few years were under the hope of finding the means of growing the same crops grown on an eastern farm. As the failures were many, and each from whatever cause meant the loss of a year's work, the experiments on this line were both costly and time-consuming. They resulted, however, in indicating such crops as might be partially or wholly successful. During the first few years, Mr. J. B. Robertson was superintendent, and was succeeded by Mr. J. E. Payne, a graduate of the Kansas Agricultural College. The results of the first few years are published in the Annual Report of the Experiment Station for 1900, and also as an excerpt in "Results of Six Years Trials of the Plains." When the Station was organized, it was expected that the State would make appropriations for its maintenance, but it did not and the expense fell upon the Hatch fund from the General Government. The Department of Agriculture has ruled that this National appropriation could not be used to maintain a sub-station.

When the present Director took charge of the Experiment Station it was evident that it was time to change the method of investigation. It was found that there were many settlers on the plains who were more or less successful. Mr. Payne was set free from the confining duties at the sub-station, provided with suitable field equipments to visit the settlements to learn their successes and failures, and especially to study the causes, whether due to crops, to local condition of soil or rain-fall, or to a personal element of a skilful and persistent leader. A great part of the Summers of 1901, '02 and '03 were spent in the field, mostly between the Platte and Arkansas Rivers. Some reconnaissance trips were also made South of the Arkansas and North of the Platte.

The previous work of the farm at Cheyenne Wells, though unsuccessful as a farming enterprise, was of great value in preparing for this work on the plains. It has already led to the publication of Bulletin 77 on "Unirrigated Lands in Eastern Colorado;" to Press Bulletins, 16, 17 and 18, on the "Prairie Dog as a Range Pest," "Trials of Macaroni Wheat," and "Crops for Unirrigated Lands," as well as to the present series of Bulletins. The Station has kept closely in touch with some of the Communities and the active individuals in the communities as mentioned in Bulletin 77. It has distributed Macaroni Wheat to many settlers on the plains in small quantities, and through the aid of the Department of Agriculture, to a number in quantities sufficient to plant several acres with good success.

These studies were made to get the facts necessary for an intelligent understanding. They show that the conditions of the plains are changing, and with the passing of land into private ownership, that the conditions of the open range are different from what they were a few years since. A large portion still remains public land and is likely so to do for years to come. In one respect it has been unfortnnate, because it is then to no one's interest to protect the grasses but rather to get as much return as possible, without regard to the killing of the grasses and the deterioration of the range which was inevitable. The range will support fewer cattle than it used to do. A consideration of the situation inevitably brings up the consideration of the range question as an important public factor. These introductory statements can scarcely be made without a word as to the irrigation of the plains, and to answer the numerous inquiries of this kind which are received. There are no running streams on the plains. There are many dry channels which contain water after floods. Some of the streams like the Republican or Cherry Creek have water near their heads which soon dissapears. The possibilities of irrigation from streams are therefore limited. It takes the water from three to five acres of mountain water shed to irrigate one acre of land. If a corresponding ratio could be maintained on the plains through storage reservoirs and catchment of floods, 20 per cent. would be an extreme estimate.

There are almost no attempts yet made for irrigation from storm waters other than catching floods in stream channels and conducting them into reservoirs. Some small attempts have been made to catch water in plow furrows on gentle slopes. The result has been promising enough to encourage further trials. There is an increasing tendency to raise water by windmills. From all these methods small areas may be expected to be developed and give a small percentage of irrigated land, with the unirrigated lands used under range conditions.

Colorado Agricultural Experiment Station

BULLETIN 87. JUNE, 1904.

Cattle Raising on the Plains.

BY J. E. PAYNE.

History in Brief. In 1867 a Massachusetts editor, when traveling from Omaha to Denver by stage, spoke of the country from Fort Kearney to Denver as 400 miles of uninhabitable space. The whole country between a short distance west of Omaha to the Rockies was considered a desert by nearly all hunters and travelers. Notwithstanding this the same men today will say that that country then supported more roving buffaloes than the number of cattle now kept on the same area. Between 1860 and 1875 the buffalo were driven out of this space and the Indians were subdued so that it was comparatively safe for men to keep cattle there. Cautiously at first, and recklessly afterwards, men went into the cattle business, until in the eighties the tally books of the various outfits whose cattle ranged eastern Colorado summed up nearly half a million head. The most of these cattle were owned by large outfits, supporting high-salaried officers and employing superintendents and foremen to do the real work. These large companies took possession of the open water along the streams and soon it became an unwritten law among them to allow each ten miles of open water and the valley adjoining it, and from the stream half way to the nearest open water on another stream or in another locality. It was the custom then to allow the cowboys to run their own cattle with those of the company and have them cared for the same as if they belonged to the company. The care consisted usually in rounding up, counting what could be found, branding the calves, and selecting animals to be sent to market.

For sometime all the range was entirely open and cattle whose owners lived on the South Platte might drift to the Big Sandy, or possibly as far as the Arkansas river. Under this system it was impossible to improve the range stock, so in the eighties the large companies began to fence large pastures and use pure bred bulls of the beef breeds. The pasture method was quite

economical as the only hands needed were enough to ride the fences to see that they were kept in repair and do a little extra work around the home ranches.

Following this era came a wave of settlement. As all the country was fenced as cow-pastures, the people had to settle in the pasture claimed by someone. During this era of claim-taking the cow-boys of the different outfits, after finding it impossible to bluff the settlers out of the country, filed in many cases on the land containing the open water of the streams, leaving the smooth upland for the settlers who came to farm.

This wave of settlement came just after the hard winter of 1885-86 had destroyed fully one-half of the cattle on the plains and had caused many owners of cattle to be discouraged and ready to quit the business. At the same time an order was issued by President Cleveland ordering all men having public lands fenced to take down their fences. This, with the crowding of settlement and the losses from the storms during 1885-86, caused the majority of the large companies to go out of business and be succeeded by men with smaller herds.

Haste of these men in getting out of the cattle business probably helped to make the period of low prices experienced in 1889-93. During these years cattle were considered very poor property, still those who stayed in the business found themselves on the top wave of prosperity a few years later when ordinary calves sold for $15 and $20 per head at five months old. But the old way of raising cattle by turning them loose and leaving them without further attention except at round-up time, had passed. The day of large herds had also passed and could not be recalled. Today a man in eastern Colorado owning as many as 1,000 head of cattle is as rare as was the man or company owning 20,000 in 1885, and between the South Platte and Arkansas rivers individual holdings of less than 500 are the rule. The majority of the cattle in that region are held in herds of less than 300. During the eight years I have been among the cattle men on the Plains the oldtimers have spoken of the winter of 1885-86 with awe, and remarked that another winter like that was likely to come at any time, "and when it does come it will clean us out," is the remark which usually followed the statement.

The winter of 1902-03 was the hardest since 1885-86. Oldtimers say that the reason the losses were not greater then was that the cattle are kept closer home and owners are able to get their cattle in and feed them. Some who attempted to winter without feed lost nearly all they had. Some fed so much that the cost of the feed was more than the value of the cattle. The owners of cattle are now compelled by public sentiment to feed so as to keep their stock from starving and they did this in 1902-03.

If they had not the losses would have been seventy-five per cent of all cattle on the Plains instead of probably less than twenty per cent as it was.

The settlers came to the country to farm and settled so thickly that they left no range for stock. After the crop failures in 1893-94, settlement was thinned so much in many communities that there was room for the remaining settlers to pasture as many cattle as they wished. From that time settlers began to gather herds about them until now the country is again almost as much overstocked by the small herds as it was before by the large holdings. Two years ago it began to look as though the grass would soon be eaten out, but the losses during the winter of 1902-03 probably checked the increase sufficiently to postpone the evil day indefinitely. Practically all settlers are now cattle owners, and many of the men own just the number that can be well cared for by the owner and his family.

Water Supply. In early days the water supply was limited to that furnished by running streams, springs and storm water which collected in basins on the prairie during heavy rains. This, during dry seasons, limited the pasture used to areas within three to five miles of water holes. This caused the grass to be badly tramped and eaten out at times near the water while there was plenty of good grass on the divide. When settlers came in on the divides they dug and drilled wells so that in a few years the whole country could be used the year round, while before wells were made the divides far from the stream were used only occasionally after heavy rains. I have observed the Big Sandy valley and the adjacent grazing land from Limon to the mouth of the creek. The upland near it was never homesteaded as was the upland along the headwaters of the Republican, so it has been left practically as it was in the days of range cattle. During the time I have been acquainted with this valley, the grass and even the sage brush have been kept eaten down quite closely, especially in winter, for one to three miles back from the water. Then the grass would improve from that point until it appeared to be practically untouched over large areas. Cattle ranging in the Big Sandy valley often go out or are driven out to some water hole on the prairie where the water has gathered during a heavy rain and remain there until the water at that place is gone when they return again to the valley.

Some of the best and most humane cattle men claim that cattle should never be compelled to graze more than two miles from water. If this be true, it would double the value of the Big Sandy range if wells were put down four miles from the stream and about three miles apart on either side of the open water. The Sand Hills are counted the best grazing land, but if they are

grazed too closely they lose the sod which holds the sand in place and again become moving hills as those of Colorado were forty or more years ago. Some of the sand hill country is considered capable of carrying forty head of cattle per square mile, while the best clay land pasture will carry only about twenty-five head per square mile.

Numbers Today Compared with Number of Buffalo and Number of Cattle in the 80's. Concerning this question we find no way of getting a fair comparison concerning the number of animals living east of the Rocky Mountains at different periods. It resolves itself into a guessing contest with no one able to decide who is the winner, and one man's guess is about as good authority as another's. Assessors' returns would be official and we believe that these are more nearly correct for 1902 than for 1885 or 1879, but we find by observation that some assessors find nine-tenths of the stock in the country they canvass while others may not find more than half. Arapahoe County comprised the same territory in 1879 that it did in 1902. An estimate made by stock men and dealers in 1879 credited Arapahoe County with 60,000 cattle and 87,000 sheep, while assessors' returns for 1902 credit the same territory with 67,000 cattle and 85,000 sheep. A few years later (in 1885) there were probably more cattle and sheep in the country than in 1879. I have tried to get estimates of the number of cattle and sheep pasturing in the county in 1885. Have received estimates from several old time cattle men. These estimates give the numbers owned by different outfits. They differ so widely that I cannot credit any of them. One gives 10,000 cattle and another 20,000 cattle to the same outfit. Taking averages of the estimates it appears to me that the stock pastured in eastern Colorado in 1885 was about equal to that kept on the some territory in 1902. But much of the stock was then kept only a part of the year and then sent to market. It is my opinion, (which I cannot prove to be true, neither can anyone prove it to be untrue) that more stock is kept the year round on the Plains of eastern Coloado today than ever before in the history of the country.

As a cattle range the territory under discussion is broken up by the irrigated lands along the Platte and Arkansas rivers which now feed thousands of cattle and sheep during winters and also by small dry-farming districts near Wray, Idalia and Colorado Springs. The adobe land in the Horse Creek region and also northeast of Hugo and other places was for a long time a death-trap for cattle companies which were managed by inexperienced men who tried to use adobe land for winter range. That variety of soil is now used only as summer range, and cattle are not put on grass there until the spring storms are past. In summer the

the grass on these ranges is extremely good, but when the soil is soaked with water, cattle cannot travel far enough on it to get enough grass to sustain themselves without gathering great balls of mud on their feet which wear the animals out completely. These factors change the conditions so much that we cannot compare the eastern Colorado of today with the eastern Colorado of 1885 and treat it as a cattle range.

Today cattle are raised mainly by what might better be called "stock-farming" than cattle raising pure and simple, that is, crop production in some form usually goes with the stock raising. Comparatively few men now attempt to raise cattle entirely without feed.

Buffalo Once Ranging Over the Same Territory. The buffalo was a range animal—pure and simple. Natural laws would govern its numbers. When the buffaloes became too numerous the feed would be so scarce that the extra number would starve and this would give the range a chance to recuperate. Old-timers have often told me that there were more buffaloes in the country in the early days than there are cattle in the same region now. Travelers told of "traveling all day through a herd of buffalo." Suppose that they did "travel all day through a herd of buffalo" how many would it take to make the show spoken of? The buffalo is preeminently a gregarious animal and it might be more than one hundred miles from one herd to another. I have seen 3,000 head of cattle scattered over a range three by five miles, and at a little distance one on horse-back, or in a wagon would consider them as covering the country as far as he could see. Then 6,000 would have covered the space for the same distance on each side. This would make 6,000 cattle on the range for every five miles. 250,000 cattle spread in that way would make the same show along the Kansas Pacific Railroad from the Kansas line to Denver. Travelers could travel for days and weeks without seeing buffalo. Also the buffalo were limited in their grazing to within a reasonable distance from water. This would compel them to congregate along streams just as the cattle do along the Big Sandy now. If there were as many buffalo watering at the Big Sandy now as there are cattle watering there, it would excite the imagination of the hunter so that he would think he saw a half million where there might be 50,000.

Pastures vs. Open Range. Only a few have tried keeping their cattle in fenced pastures. Those who have kept their cattle in such a way find it more a question of water supply convenient and sufficient than of range. Without doubt if the whole range was divided into numerous small pastures with plenty of good water conveniently located in each, so that no animal had to walk more than one or two miles for water, the country could support

a much larger cattle population than it does now. The cattle could be moved from one pasture to another so that one pasture could recuperate while the cattle were grazing in the others. This plan when tested in Abilene, Texas, increased the value of the pasture quite rapidly. The important question in every case is the water supply. If only one square mile is available, then dig the well in the middle as nearly as possible and fence in four pastures and have watering troughs in each of the four pastures into which the tract is divided. Such a small holding as this would necessarily mean a dairy in connection and cows of the dual-purpose class. Those having larger areas under control could afford to raise beef cattle exclusively and all could improve their stock at their convenience without interference from the scrub stock kept by neighbors. The expense of fencing is the main argument against the keeping of cattle in pastures in communities where the land is all in the hands of private parties. But in a few years the amount which is saved in wages for hunting stray cattle and following the round-ups will pay for the fence. Also the owners always know where the cattle are and if he wants to sell one the buyer does not have to wait a week or so until the cattle can be found. Of course as long as there is Government land the pasture idea cannot be used fully, but it can be used partially. At present the men who own land often fence their own land and save the grass on it for winter range for their stock, running their stock on the open range in summer.

The use of "drift-fences" on government land is often quite beneficial to all who use the range partially enclosed by them. Often combinations of them almost enclose large tracts of pasture land. These immensely reduce the labor of controlling the cattle and keeping them on their own range. I have seen 3,000 head of mixed cattle handled by two riders by the judicious use of "drift-fences."

Range Improvement. Improvement of the range under present conditions may be classed with "iridescent dreams" of the cow man. No man is considered a good business man who will spend his money, strength and thought in improving something which is subject to being taken possession of by another as soon as it appears to be desirable property. For this reason the prairie dogs are allowed to increase while the cow-boys ruthlessly kill every hawk, badger, rattlesnake, and bullsnake that they can, thus leaving the real enemies of the range (the prairie dog) to increase without hindrance until they make their homes in the front yard of the "home ranch." Occasionally a prairie dog is killed for sport, but such cases are comparatively rare. Usually the range deteriorates so slowly that its lessened value is not noticed until some extremely dry summer or very severe winter.

The range cow-man is accustomed to seeing large numbers of cattle very poor and is not surprised when several of the poor ones die. He takes the hide and philosophically remarks that "the old cow's time has come." When cattle are high in price the range man buys cattle to the limit of his credit instead of the limit of his pasture and winter feed. The rule is, the more cattle a man has the less winter feed he gets stored for them. Then after running all summer on an overstocked range the cattle start into winter poor. In buying the cattle it is likely that the man has bought a goodly quantity of mange and contagious abortion. If to this combination is added an unusually cold winter with much snow evenly distributed so as to cover what little grass is left, then the greatest factor in "range improvement" under present conditions, thinning out by death from starvation, gets to work. After the winter is over the creditors take what is left and the range is allowed a few years of comparative rest, while the same man or others gain the "*nerve*" to restock it to its capacity. Eras of extremely low prices for feeder steers work the same beneficial results in range improvement as in the above case.

Methods of range improvement have been suggested in another paragraph. As yet we have found no grasses better than our native grasses, so it seems that the best way to improve is—rest and time for recuperation.

Winter Feeding. Twenty-five years ago a cow man in western Kansas remarked "If there was a hay stack on my range which my cattle could get to, I'd burn it and pay the owner for it rather allow my cattle to eat it." That kind of talk has been very popular among the cow men on the plains. But during the past few years the sentiment in favor of feeding during the winter has grown rapidly. Chief among the factors which have brought about this change of sentiment is the Humane Society which now has agents who travel over the plains looking for cases of cruelty to animals. Some say that most cattle men are subject to fines if the strict letter or spirit of the law was enforced. Some make no attempt whatever to provide feed for their cattle, even for times of storms. Some prepare to feed during storms and very few put up enough to feed all winter, practically none do this. Usually six weeks feeding would exhaust the feed of the man who has put up the most feed. In ordinary winters it is only necessary to feed all cattle during storms and the weak ones all the time. The feed which can be raised consists of roughness such as corn fodder, Kaffir corn, sorghum, wheat, barley and rye hay and millet. I have found sorghum and some varieties of flint corn to be the surest crops tried on the Plains. These practically never fail to produce fodder. Many find spring rye the most economical crop to raise and some stick to millet as best for

their conditions. I would not advise anyone to try to raise any of these crops by dry farming on adobe soil, but on sandy loam or the lighter clay soils these crops are fairly sure to pay in a series of years. Sorghum fodder can be produced at a cost of $2 per ton in a series of five years on sandy loam land. This will certainly be cheaper feed than shipping in feed, hay and corn.

When cattle are pastured during the summer on adobe land it is necessary to get them to some other place for wintering. Those who pasture the adobe soil near Horse Creek usually take their stock to the Arkansas Valley to feed during the winter. Hundreds of cattle are wintered now in the little nook of farming country about Wray, Vernon and Idalia. In the winter of 1902-03 many took their cattle to that country to winter and thus saved a large per cent of them from starvation. Some of the cow men have not fed a cow for so long that they have no idea how much feed an animal needs. Some men feed such a small amount that it will not sustain life, while others feed so much at the first feed that often animals are foundered and never recover. Many feed grain altogether when they feed during the winter, and allow their cattle to get their rough feed from the prairie. The way roughness is usually fed, strong cattle will not rustle for grass after having been fed a small feed of fodder, but will if fed a small feed of grain. I have seen fodder fed by scattering it over the range. Those who fed their cattle in that way claimed that the cattle would eat the fodder and then go on eating grass the same as they would if they had happened upon a few bits of grass which grew taller than the ordinary grass. This method can be used when a man can keep stray cattle away from his herd.

It has been the experience of cattle men that after they have begun feeding an animal the feeding must be continued until the grass comes. It is also better to feed the weak animals full feed instead of trying to make them rustle for a part of their living. If given a partial feed they die and all that is given them is lost, while if well fed and sheltered they get through the winter in good shape and are soon equal to the stronger cattle that rustled all winter.

Shelter. This is one of the most important factors in stock raising. Cattle kept warm and dry do not need as much feed as those exposed to the rain, snow and winds of winter. A cow covered with an overcoat of frozen snow soon loses ability to eat and her owner is lucky if he gets even her hide. If both food and shelter cannot be furnished, shelter should be chosen, because cattle in warm quarters, like a sod-sided shed covered with a water-proof roof, will go out on the range after a three days' storm and soon fill up on the dry grass, while without shelter cattle can eat very little during the storm. Fodder and hay cannot be fed

in an open lot during a wind storm, and it is very hard to feed grain even in troughs in the open during the progress of a storm. But as a rule those who have no further preparation for shelter than a corral made of barbed wire seldom have to face the problem of feeding their cattle there during a storm. Usually their cattle are scattered over the range sometimes as much as fifty miles from their home corrals. Such cattle are lucky if they range in a hilly country as they can then find some shelter in the gullies and beside bluffs along the creeks. In rough country the snow does not usually cover all the grass as there are so many varieties that grow comparatively tall in such locations, instead of being limited to a few inches in height as are the grasses which grow on the level lands.

Diseases. During the time of high prices, cattle were shipped into eastern Colorado from many places and nearly every man there bought cattle to the limit of his credit. With these cattle were imported a few undesirable diseases. Diseases like opthalmia could be seen, and the man who bought cattle affected with those could blame himself. But itch or mange was not in evidence among the cattle during the summer so as to enable a man to see it on wild cattle. Neither was contagious abortion visible when the cattle were shipped into the country. But the next winter after the cattle came in, itch developed in a large proportion of some importations, and some herds of fine looking heifers, which were sold at high prices, were found to be infected with contagious abortion to the extent of ninety per cent in some cases. The contagion spread to the sound cows which were in the herd before the purchase of the strange cattle. The remedies for these diseases were simple, but extremely expensive. The mange on the cattle had to be destroyed by dipping the cattle, and the corrals and all scratching places disinfected. If these measures were thoroughly carried out all over the country, the mange would be stamped out in a season.

There are various remedies suggested for contagious abortion, but the most effective one is to send the whole herd to the slaughter house and stock the range with calves, or with cattle from a range where the disease does not exist. Afterwards when one sees a fine-looking lot of young cows offered for sale, he had better leave them alone until he knows their history or the condition of the herd from which they came.

There is one neighborhood where I have never heard of a case of contagious abortion and practically no mange. In that neighborhood no cattle have been sold by the speculators. Those people started several yeers ago with only a cow or two apiece and have bought no cattle except bulls since.

Loco. This is one of the bug-bears which lurks about the range country. I have never found a man who has seen enough of the progress of a case of locoed animal to be able to give a complete history of a single case. The history given is, "I turned a horse out one time and did not see him for several weeks. He then acted strangely. I saw him eating the loco plants and later he would eat nothing else. He became weak and emaciated and finally died."

I have seen a great many animals that were said to be locoed I have seen a few eating loco plants. I have also been, in a few cases, unsuccessful when attempting to make a "locoed" animal eat the loco plant. At one time we heard of a man who had 200 steers, ninety-five per cent of which were said to be locoed. We spent sometime on that range and we could not find enough of either loco weeds or brown sage (which was also accused of causing the trouble) to support an animal more than a few days. The loco plants growing in the pasture where quite a number (about fifty) of the locoed steers were confined, were mostly untouched by them. We saw a few plants which had been partially grazed off. I tried to feed green loco plants to a steer which was confined in a shed. He would not eat the weed, but ate corn and alfalfa hay with a relish. The range on which these steers were kept was a very poor range. There was very little grass which they could get. Later one steer which was badly affected when I was at the range the first time, died, and the bone of one hind leg was found to be decayed so that it broke with but a slight pressure.

In every locality where loco was said to be prevalent I found the range to be very poor. This scarcity of food seems to go with loco outbreaks. I have often found a scarcity of loco plants as well as a scarcity of edible grass. At one place where I saw loco plants so thick that at a distance the patch showed but little else except those plants, the party using that range told me that his herd had never had a case of loco.

I have noticed that there is more talk of loco when there is danger of new settlers coming in on the ranges occupied by old-time cattle men than at any other time. A "terrible outbreak" of this kind occurred just as the U. P. Land agents began to bring buyers into the country four years ago (in 1900). Some of the parties who talked the most about loco have since told me that the U. P. R. R. was getting to "thinking too much of their land and putting too high a valuation on it, so the old settlers there wanted to show the Railroad company that the land was not worth so much." Others told me that an animal would not eat loco until it was almost starved to death.

Such a variety of symptoms are described by different parties who describe locoed animals that it is possible that quite a num-

ber of as yet unnamed diseases (at least unnamed by the stock men) exist on the range, and whenever an animal acts queer it is called "locoed."

The remedy usually applied is to take the animal away from the range upon which it has become diseased and feed it plenty of nutritious food.

Financial Results of Stock Raising. The main question at issue is, "Does stock-raising on the Plains pay?" The answer cannot be a definite "yes" or "no." The results of a venture depend upon the man behind the business, and also upon the conditions which he happens to meet in the work. We have known some men who made money raising cattle when prices were lowest and have met others who have broken up when prices of cattle were at the highest point. Close attention to details, an accurate acquaintance with the conditions existing upon the range used and good judgment in buying and selling are all among the factors which give success. If the herd is small the cows must be milked in order to make the profits sufficient to support a family. A man with ten cows can make a good living for his family and get ahead financially if he selects cows which give a fair amount of rich milk, and milks and cares for them properly. This man can raise feed enough to feed seven months in the year and keep his young stock growing all the time. He has but a small amount invested, and therefore his taxes are light. His stock stay near home and the expense of hunting for strays is small.

The man who has one hundred cows must hire some work done even if he raises no feed. He will be lucky if wintering does not cost him at least $3 per head in feed and losses from starvation. If he sells fifty head of cattle at $25 per head, his total income will be $1,250 per year. Out of this he must pay all store bills, feed bills, lumber bills, etc., and by the time he has paid all bills and the interest on his investment he may not be ahead of his poor neighbor who milks the cows. But one man cannot figure out the results in advance for either himself or another and get them as they will come out in actual practice. Taking it all around the personal factor is the main one in this, as in every other business venture.

Colorado Agricultural Experiment Station

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Dairying on the Plains.

By J. E. PAYNE.

History. During the days of mail coaches a milch cow was a curiosity on the Plains west of Fort Kearney. Probably the old hunters occasionally captured a buffalo cow and amused themselves trying to extract enough lacteal fluid to tone their strong coffee, but I doubt that their efforts were successful, except as an amusement. Those were the days of condensed milk, and they all found it easier to milk the can than to can buffalo milk. Later, when the Texas longhorns had taken the place of the buffalo, the cowboy who had the hardihood to try milking the dun Texas heifer probably extracted as much fun per quart of milk obtained as did the hunter who milked the buffalo "bossy." When the large companies took possession of the country, the horde of high-salaried officers who occasionally visited the "home camps" of the companies, had to have more delicate food than the jerked steer and drop biscuits which prevailed at many cow camps. So good milch cows were brought in and kept in enclosures near the permanent camp or home ranches of the outfits. These supplied plenty of milk, cream and butter and enabled the cooks to manufacture dishes fitted for the palates of the rulers of the range. Of course the old hen also lent her portion to the feasts. Ranches fitted in that way were exceptions in those days, but some of those located hundreds of miles from towns would be able to furnish many luxuries to the visitor.

When settlement first came into eastern Colorado there was a good local demand for dairy products. A few settlers brought cows with them, many had worked at dairying in their old homes and they saw the opportunities open to them in that line in the new country. When new settlers were constantly coming into the country, times were good and poor men could live by working for those who had brought money with them. But when the hard years of 1893 and 1894 came, this source of revenue for the poor man was cut off. Most of the men who had extra riches left the

country, or ceased making improvements. Then the poor man who had no cows could not stay in the country. He had to go where he could work for somebody. Those who had a few cows and a flock of chickens could stay and many of them did stay where they were by taking care of their cows and chickens. Many of these people had not enough property at that time to sell for enough money to pay their little store bills and pay their car fare to their old homes. Many old settlers have told me that they were "unable to leave the country during those hard times, so they stayed and grew comparatively rich."

In 1895 beef cattle increased in price, and the increase continued in 1896-97, until almost any calf would sell for $12 to $20 when old enough to wean. With beef cattle at these prices, it became more profitable to raise calves than to milk the cows and make butter. Also, those who had a few cows in 1893 had so many by 1898 that they could make a living from the herd without milking the cows, and often they had not much time for doing much dairy work when they had so many cattle to look after. Herds continued to increase until the range was overcrowded so much that the calf crop grew lighter, and often many of the cows would starve to death during the winter. A period of speculation came in 1901 and 1902, when many of the settlers bought cattle to the limit of their credit. This overstocked the range almost everywhere on the Plains and this overstocking caused immense financial losses. With many it again became necessary to begin milking the cows in order to get money to pay the interest on the money they owed. So we found many cows being used for dairy purposes in 1903. The low prices obtained for feeder steers compelled the people to milk their cows. During the early days attempts to support creameries were made at a few points, but these failed for lack of patronage when beef cattle took the country. A skimming station has been in operation at Burlington a few months at a time for several years. This was not in operation in 1903 as it had been superceded by hand separators.

During the past two years hand separators have grown in favor among dairymen. They find that they can raise better calves by giving them the freshly skimmed milk than they could by feeding skim milk which had been to the skimming station and back. Also, by use of the hand separator, they take only the cream to market and thus avoid handling so much weight uselessly. In 1903 there were ten hand separators in use near Wray, ten near Akron, about the same number near Burlington, and one at Cheyenne Wells. I also heard of some being in use at other points.

The cows first in use for dairying were such as were brought

to the country by the settlers or such as could be bought at the ranches. The dairy type of cows had a chance to become prominent during the hard times. In 1896 there were some Holstein and Jersey cross-bred animals in the country. But as beef cattle rose in price the dairy types of cows diminished until now they are hard to find. Cattle which are grades of one of the beef breeds are seen everywhere. In Washington county, Polled Angus and Galloway grades occupy most of the range. In Yuma county the honors are about even between Shorthorns and Herefords. The same is true of Kit Carson county. In Cheyenne and Lincoln counties Hereford grades predominate, but the other three leading beef breeds are well represented. Then there are many Mexican cattle in some of the country which is purely a range country. Practically all the cattle on the plains in other counties, as well as in the counties named, are of the same character. Nearly all of the cows have been allowed to run with their calves during the season. Very few of them have been touched by the hand of man, except at branding time.

Cows raised and trained in the manner described and which are cross-breeds of beef-making breeds instead of dairy breeds, are not likely to prove to be very profitable dairy stock. After the settler has decided to return to dairying, it will require two or three years to train cows for the business so as to make it profitable from the business-man's standpoint. The range cows give milk during only about five months of the year. They must be trained to give milk during ten months. The cow that has become accustomed to running with her calf will not readily consent to adopt a man to take the place of the calf. If forced to submit to being milked by a man, she cannot be compelled to give all her milk. In order to get a herd ready for dairying, the heifers must be broken to milk and developed as milch cows. By choosing the best from large numbers, a herd may be obtained which will give some profitable returns the second year. If the heifers pay expenses the first year, they will do well. Some men milk a large number of cows after the calves are weaned, getting a little from each cow for a short time. This is pure gain to the man who does his own work as nothing is fed the cows and they are milked in order to keep the udders from spoiling.

Some milk their cows during the summer, or during the time when grass is good, and allow them to go dry when the cold weather begins and it is harder for the cow to get plenty of feed on the prairie. With the average range-bred cow, this is probably the best way, because she will not respond to heavy feeding by giving more milk. Instead they will put on flesh when fed heavily. When they have dairy cows they can then find profit in feeding costly feeds during the winter. As it is now it will re-

quire from one to five acres cultivated in sorghum to feed a milch cow through the season of poor grazing. A man who has ten cows can milk them and raise enough feed to feed them and their calves through the winter. The feeds that he would be likely to raise are wheat and millet hay, corn fodder and sorghum. Some years he would raise enough grain to make a good ration for the cows, and during some years he would have only roughness which he could profitably use with some of the concentrated feeds which are on the market. At present practically all the settlers use the forage and grain which they can produce and buy as little as possible. Ensilage should in the future be a part of the winter rations of the milch cow. I have frequently been asked about ensilage by settlers who were thinking of doing winter dairying. No trouble should be experienced in making good ensilage anywhere on the Plains. In fact the Australian stockman makes ensilage by stacking the green forage above ground just as it is cut, and weighting the stacks heavily. I would not advise this, however, because forage is too scarce on the Plains to afford to waste the amount that is lost by making ensilage in the stack. In many locations it is easy to make a pit near the bank of a creek or ravine so that a door may open from it into the ravine. This will resemble the costly silos which are built above ground. On level ground an immense cistern will answer the purpose perfectly. These underground silos will be used at less expense than the silos built above ground, as the green fodder does not have to be elevated. It can be merely thrown into a pit and trampled down solid. Of course the pit will be better and more substantial if the walls and bottom are cemented. In filling the silos the green forage should be run through a cutting machine and the stalks should be reduced to pieces one half inch to one inch in length. An ensilage cutter suitable for filling small silos which can be run either by a windmill or by horse power can be bought for about $40 or $50. By making the green feed into ensilage the waste caused by the hay and fodder being covered with dust by the wind storms, may be avoided. The pit silo can be made by the home labor with no cash outlay. After it is filled it should be covered to a depth of one and one half to two feet with hay or straw, or any trash which will keep the dirt out of the cut feed and then earth should be thrown upon that covering to weight it down. About one foot of earth should be enough, but the weight of earth should be put on according to the depth of the ensilage in the silo. I have seen one foot of earth put upon eighteen feet of ensilage with good results.

Shelter. In nearly every locality good sod is available for building purposes. The adobe soil furnishes the best sod for this purpose, but any stiff clay soil will make a strong wall. Light

sandy loam soils do not make good soils for building. The wall may be built two feet thick of sod, then a good roof of either lumber or shingles should cover the building which is to be the winter shelter of the dairy cow. Some make the covering of rough boards and lay sod on top of the boards. Some thatch the building with sorghum or other rough hay. All the coverings except those of wood must be frequently renewed or they leak so badly that the building ceases to be a shelter.

Results. Comparatively small returns from dairying on the Plains are the rule. One creamery man remarked to me that "a settler could milk a three-year-old steer out of a cow every year." That may be true but in order to do that the cow must be fed, and it will be a good steady job for one man to milk twenty cows and raise feed for them. If then, three-year-old steers are worth $35 each, a man by hard and confining work, may get $700 for his years work. This is a theoretical illustration. Usually one man and his whole family manage the twenty cows or less. Some parties near Akron report a return of five dollars per cow during five months in 1903 from grade Shorthorns. This is a report from only one season's work, presumably with a selected herd of cows.

One of the oldest dairymen in Burlington, a man who never quit the business since he came to the country fifteen years ago, milks twenty grade shorthorn cows and heifers every summer, He tries to raise good calves as he counts the calves as his profit. His estimate is that the average range cow running on buffalo grass and getting no other feed will give about two dollars worth of cream per month during six months of each year. By milking enough cows the settler can make his living from the cream sold, and the calves will be the gain.

At Wray the estimates were similar. That is the cream will make expenses leaving the calves clear gain, and the weight of evidence all around pointed the same way. Of course, the better beef animal the calf is, the greater the gain, and the nearer the cow approached the dairy type the more cream she would have to yield in order to make up to her owner the difference between her bony calf and the fine calf of the grade shorthorn.

We may safely count dairying, in a modest way, a success from the standpoint of the settler in eastern Colorado. This is especially true when it is practiced in connection with the production of medium to good feeding steers. Of course choice steers cannot be produced in connection with dairying on the range without using so much feed that the cost is likely to be too great for the returns obtained. If the dual purpose cow has a place anywhere it is on the Plains of eastern Colorado, where men

must milk the steer's mother in order to be able to keep the steer until old enough for the feed lot.

Dairying is a confining business, but it is a business which will give employment at modest wages to all who are able to get a few cows and settle on a piece of government land. With dairying the plains country will support five times the population it will support under the system of raising beef alone. All who can get a location within fifteen miles of a railroad station can sell cream. Those farther from shipping stations would better work at cheese making which has proved very profitable in many localities.

The greatest source of profit in dairying in eastern Colorado is not in the production of dollars or steers, but in the training of the boys and girls to habits of thrift and industry. Where no cows are milked about the only thing left for the children to do in the purely stock-raising sections is to ride around the country on ponies and drive cattle. If any feed is raised they may work in the crop-raising a part of the season, but the chances are that they will grow up comparatively idle and not learn to do any work systematically. But with cows to milk and care for regularly and the calves to feed, there will be something for every child to do who is strong enough, and each member of the family may be helping to earn something to provide luxuries as well as necessities. Also, the income from the sale of cream will come monthly, while if the sale of steers is depended upon the income. as a rule, comes yearly.

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Wheat Raising on the Plains.

BY J. E. PAYNE.

Eastern Colorado was settled mainly by people from Kansas and Nebraska. These people had raised wheat as a main crop in their former homes and as a matter of course began planting wheat when they came to the new country. The usual successes and failures followed. In 1892 an immense crop was raised, but 1893, 1894 and 1895 were hard years for the wheat growers. The years following were not so bad as 1893 and 1894. Wheat planting began in earnest in 1888. The average of wheat per acre reported by a number of representative farmers now living near Vernon and Idalia for the eleven years, 1888 to 1899, inclusive, is ten bushels per acre. This includes the years when the crop was an entire failure, on account of drouth, hail or insect enemies.

In common with other new countries, this country seemed poorly adapted to the growth of fall wheat when it was first settled. Many tried fall wheat, and sowed it until they lost their seed and then quit. In 1900 there were only a few small fields of fall wheat in the country, but a series of comparatively damp autumns have encouraged the settlers to again sow fall wheat, until in 1903 fields of fall wheat were seen to be quite common. Those who grow fall wheat claim to get one to two bushels more per acre from it than they get from spring wheat, and the buyers pay five cents per bushel more for it than for spring wheat, so there is considerable inducement offered for trying to raise it. On the Idalia divide, about one half the wheat seen by me in 1903 was fall wheat, while on the Vernon divide about ten per cent of the wheat was fall wheat.

During the years 1902 and 1903, a spring variety of macaroni wheat has been introduced into the country. It is a hard wheat and seems to be quite drought-resisting, although it has as yet, given only about the same yield as the ordinary spring wheat. About 2500 bushels of this wheat were grown on the two divides in 1903. For a time the growers seemed unable to find a market for their macaroni wheat after they had raised it, but when deal-

ers in Kansas City learned that they could buy it by the car-load, the growers found no trouble in selling all they did not need for home use. Local millers and dealers thought that they could not handle the wheat. Millers needed special machinery for getting all the flour out of it and local grain dealers were afraid to handle it lest it should become mixed with the other wheat and render it unsalable. Recently a miller at Fort Collins has been trying to get macaroni wheat for sowing above the ditches where irrigation is impossible. He promises to buy all that can be raised at the same price that ordinary wheat commands.

Varieties of wheat used in the most of the wheat-growing districts are not usually known. Certain types of seed wheat happened to survive the drought years, either successfully resisting the drought or by having been kept in granaries through these years, have since been sown continuously. These are now known as "white wheat" or "red wheat" sometimes with the name of some settler prefixed to the type-name. I failed to trace the origin of any of the seed used, but believe that quite a number of varieties are grown there, usually very much mixed now. When the macaroni wheats were introduced, it was feared that they too would become mixed with the other varieties and reduce the value of the common wheat. In time the growers of macaroni wheat may fear that the soft varieties may become mixed with macaroni wheat and reduce its market value.

Preparation and Seeding. Probably almost every method of preparation of the seed-bed and planting has been tried by someone at some time since settlement began. In some years success "chased" the farmer who used the most slovenly methods, while in other years she outran and kept out of reach of the man who used the best methods known in the art of farming. This happened so often that some settlers have contracted the habit of putting the seed into the ground by use of the least possible amount of work, and they say they are sure of a good crop if the rainfall comes right, and are sure of a failure if the rainfall does not come right, no matter how the grain is planted.

Following out this idea, some have continued to sow the seed broadcast, either with a broadcast sowing machine which is attached to a wagon bed, or by hand. The seed is sown on the ground which has received no preparation to fit it for a seed-bed. Weeds may cover the ground, or it may be bare. The seed is then covered with either a corn cultivator or a disc harrow. Sometimes the ground is not harrowed after the seed has been covered, and sometimes it is harrowed with a smoothing harrow.

Some good farmers tried plowing the ground thoroughly before sowing the wheat. But after a time so many failures were received by using this method that the best farmers ceas-

ed to plow their ground for wheat. As a rule the ground which is plowed for wheat is not worked enough to make a good seed bed for the plants. So the soil dries out and injures the crop when droughty periods come. With ordinary tools it is next to impossible to make a seed-bed sufficiently compact for the wheat plant after the soil has been plowed shortly before sowing. Too much air space is left in the soil and this is fatal to the feeding roots of the wheat plant. With special tools for packing the soil after plowing an ideal seed-bed may be made. But this requires so much work that one man could not seed a large area to wheat as is the custom now. It is possible for one man to plant 300 or 400 acres to wheat, but if he plowed the land and then prepared it properly after plowing, he would be able to plant only 80 or 100 acres. In seeding on plowed land, the hoedrill has been used. The press drill is superior to the hoe drill as a machine for planting where drought is so often a prominent factor in determining the results. The disc press drill is also considered an especially good tool for use in the dry farming country.

For a long time some farmers claimed that broadcasting the seed and then covering with a disc harrow or a cultivator so as to thoroughly stir all the top soil and put the grain into the ground in contact with firm soil was the proper method to sow wheat. Then the disc seeder was invented. It did, at once going over the land, exactly what they held was best. With plenty of teams, a man could put in a large acreage single-handed, then if the crop was a failure, he wonld lose nothing except the seed and his own labor, while if the crop was good, he could well afford to hire plenty of help to harvest and thresh the crop. But as land becomes more valuable, I notice that more work is put on the preparation of the soil, and seed drills grow in favor.

When I first visited the wheat growing district of eastern Colorado, many of the best farmers told me that they had grown wheat on the same ground year after year, sometimes as much as ten crops in succession, and the soil did not show any signs of being worth any less for wheat growing than it was the first year wheat was sown upon the land. Two years later all admitted that the land was surely failing when wheat followed wheat. In 1902, I noted fields which demonstrated the difference between wheat after wheat and wheat after corn. In some cases wheat following wheat gave a yield only five bushels per acre, while wheat following corn in the same field, produced fifteen bushels per acre. It is now generally admitted that it does not pay to sow wheat after wheat. The rotation usually practiced is corn one year and wheat the next.

Fall plowing for spring wheat has not been a success. The best explanation for this is that during the winter the soil dries

as deep as it is plowed and this through drying seems to lock up the plant food temporarily so that the wheat plants do not grow well. Sorghum before wheat is bad for the yield of wheat, in fact it seems that any crop which is not cultivated thoroughly during the growing season is a poor one to precede a wheat crop. It is probably true that if the corn is not thoroughly cultivated the yield of the wheat crop following it will be materially reduced. One man has for a few years practiced listing his ground in the fall for the wheat crop of the next spring. He reports an increased yield of from one to two bushels per acre by using this method, as compared with the ordinary method of preparing the ground. One year a heavy rain came after a part of the ground was listed. The next year that part of the listed ground which was packed down by the rain gave no better yield of wheat than the ground prepared in the ordinary way.

Crops Raised Outside the Main Districts. Wherever one goes he hears of the enormous crops of wheat raised in 1892. At Akron the visitor found wheat piled up everywhere during the fall of 1892. They could hardly get cars enough to carry it out of the country. Yields of 30 to 40 bushels to the acre were common. At Thurman about the same yields were obtained. Settlers at Cheyenne Wells and Burlington also obtained heavy yields of grain that year. But outside the Vernon and Idalia divides, very little grain has been produced since. This may not be because it could not have been produced, but because the droughty years following caused nearly all the settlers who did not favor making a stock country of the region to become discouraged and leave the country, leaving its population sufficiently thinned to permit those remaining to have all the free range they could use. Under these conditions stock-raising was so profitable that the settlers could not afford to raise wheat.

Soils and Other Influences. The soils of the Plains are quite well adapted to the growth of wheat. This has been proved whenever the rainfall has been properly distributed during the growing season. The soils near Vernon, Idalia and in the eastern one-third of Kit Carson county, are very much alike, and under similar conditions, would produce about the same yields of wheat. But the Vernon divide is protected from the ravages of hot winds by the groups of sand hills which lie on the northern and western sides of it, each of these groups being about twenty miles across. The influence of the sand hills dwindles rapidly as the location is farther to the south and east. The Idalia country is not quite so free from hot winds as is the Vernon country. By the time Burlington is reached the influence of the sandhills is practically nothing, while at Cheyenne Wells, one could not possibly know that the hot winds were tempered by any influence. These sand

hills absorb all the water which falls upon them. They also receive in addition the drainage from about as large an area as they cover which lies west of them. They seem to cover the lower courses of the streams which start on the clay lands west of the sandhills. This moisture influences the humidity of the area which the hills partially surround, and while the rainfall is practically the same at Wray as at Cheyenne Wells, the air is more humid and so does not absorb the water from the soil and from vegetation so rapidly as does the air in less protected localities.

The rule seems to hold good that the greater the percent of clay a soil contains the more water it must have in order to produce a crop. It is a noticable fact that during dry years the men living on black sandy land produce better crops of all kinds than those living on clay lands, but where the rainfall is abundant the clay lands will give larger yields, especially of wheat, than the sandy lands.

One encouraging fact which should be here noted is that the samples of macaroni wheat grown in eastern Colorado have been pronounced to be the best seen which has been grown in the United States. The rainfall is never enough to damage the quality of macaroni wheat. From present indications it is possible that in a few years very little wheat except macaroni wheat will be grown in eastern Colorado, and it is also likely that the wheat-growing districts will be greatly enlarged by the use of this variety.

Use of Straw. For a long time the wheat-raisers had little use for their straw. Sometimes the straw would accumulate for several years if it was not burned, but during the past four years they have been wintering cattle in the wheat growing districts because the range has become so crowded that there was no winter range in many localities. This influx of cattle from the pastures surrounding the farming districts has furnished a profitable market for all the straw which is produced. At the same time the feed raised in the farming country has saved the lives of thousands of cattle.

Results. The real results of a business are not correctly estimated if only the volume of the business is known. While the yield of wheat per acre will not average more than eight bushels on the two divides during the fifteen years it has been grown there, that does not tell of the profits and losses sustained by the settlers. Of course the settlers have been forced to raise corn in order to raise wheat. Then they raised hogs because they raised corn. They gathered cattle because they had so much rough feed as a by-product from the wheat and corn raising. This has changed the period during which the farmer had employment for himself and family from 90 days during the year

which was necessary in wheat raising alone, to 365 days which is necessary under the mixed farming of the present day. Some men have lost all the property they brought to the country, but others who came with practically nothing are quite well-to-do now. The banker at Wray, who is an old settler himself and is personally acquainted with almost every man on the Vernon divide, especially from a financial standpoint, told me that a large majority of the settlers there are better off, financially, than they were when they came there. The good dwellings and barns seen there seem to prove the statement.

Magnitude of the Wheat-growing Industry on the Plains. At Cheyenne Wells, no means of threshing grain is available except a little tread-power machine. At Burlington, very little threshing is done because no threshing machine is near enough to afford to come there for the work it can get. The wheat there is used for feed, usually for hay. At Yale, several stone rollers are in use at times when a crop of grain is raised. At Seibert, there is a small horse-power thresher which usually operates near Tuttle, Kirk and Cope. At Thurman is another small horse-power which threshes a few jobs each season. At Akron I saw no threshing machine. The flail is the only weapon in use there at present. But on the Vernon and Idalia divides, nine threshing outfits are in operation nearly every year. Some of these are large steam-threshers which carry hands enough to do all the work so as to deliver the grain to the owner's wagons. Often the machines are all busy from the middle of August until far into December. Of course the machinery in use for threshing indicates the relative production of grain. There are three grain buyers at Wray, and besides what these men buy, much goes to Haigler, Nebraska, St. Francis, Kansas, and Burlington, Colorado. There is a good flouring mill at Wray and another at Burlington.

Next to stock raising under the range system, wheat growing requires fewer days work in the year than any other farming business, so wherever wheat can be successfully grown, farming may gain a foothold. Where it fails habitually, the stock must occupy the country.

Colorado Agricultural Experiment Station

BULLETIN 90. JUNE, 1904.

Unirrigated Alfalfa on Upland.

BY J. E. PAYNE.

Since the wave of settlement flowed into eastern Colorado in 1886, men in isolated localities have been testing alfalfa as a forage plant for the unirrigated lands.

During my travls I have had several small plats of alfalfa under observation, usually seeing the crop one or more times during each year. Near Vernon, Robert Brady had a field which he used for a hog pasture for several years. The plants kept dying out until there were practically none left. Another patch near Vernon survived as much as five years or more. It was cut for hay a few times. One year it was nearly three feet high when cut. When seen in 1903 it still showed a thin stand. Another patch on the same farm was sown in the spring of 1900. In 1901 it gave a heavy crop of hay, but has not grown tall enough to cut since. Jas. Slick had a small field of alfalfa which he used as a hog pasture for several years. The grasshoppers destroyed what was left of it in 1902. In 1902 he sowed five acres, but the grasshoppers have kept this down so that so far it has yielded very little forage. Russian thistles also came in and occupied the field as soon as the alfalfa plants were killed out.

Near Logan, Geo. Bond had about four acres in alfalfa which he used for hog pasture for several years. He thought that it payed well. A. C. Brown, who lives on the Kansas line about seven miles northeast of Lansing, had three acres in alfalfa when I saw the place in 1900. This patch had been seeded about seven years then. Mr. Brown told me that he cut it twice some years, once some years and during some other years it did not grow high enough to cut for hay. The average yearly yield of hay Mr. Brown estimated at one ton per acre.

Near Idalia, John Gillespie sowed eight acres to alfalfa in 1902. Both 1902 and 1903 were so droughty in his neighborhood that he has not yet cut a hay crop from it. The same experience was met by John Reidesel and Chas. Ingalls, and also by some others who sowed about the same time. Near Vona, S. L.

Howell sowed five acres to alfalfa in 1902 with the same results as were obtained in Idalia.

In 1897 one half an acre of alfalfa was sown at the Plains substation at Cheyenne Wells and a good stand was obtained. The weeds were kept mown down that year. In 1898 one half a ron was cut from the plat at one cutting. The grasshoppers took the other cuttings. In 1899 the plat was mown once for hay, yielding about one-fourth of a ton. The grasshoppers killed many plants and the Russian thistles took the place of alfalfa. In 1899, 1900 and 1901 there were fewer alfalfa plants left each year and no hay crop was cut either of those years. By 1901 there were so few alfalfa plants left that the land was planted to another crop.

Again in 1899 four acres were seeded to alfalfa May 20th. A good stand was obtained, but during the hot summer weather that on the higher land died. About one acre on low land which was occasionally overflowed by water drained from the prairie across it continued to grow well. In 1900 this part yielded one cutting at the rate of one ton per acre. Grasshoppers gradually killed this patch out until in the spring of 1903 so little was left that it was plowed up and the ground planted to other crops.

Planting. The important factor in getting a stand of alfalfa is getting a good seed bed for it. My experience has taught me to plow the ground early in the season five to eight inches deep, harrow until it is thorougely packed and then wait until the ground is thoroughly wet before planting the seed. If this occurs before the middle of July go on the ground with a light drag harrow as soon after the rain as the surface appears to be dry and break the crust thoroughly. Then sow the seed broadcast and follow with the harrow. A good stand has been obtained every time I have followed this rule, but if a drill is available the same rule should be followed except that the seed should be drilled in as soon as the ground shows dry on top. Some have been successful with the hoe drill and some have used the press drill. One man seeded his alfalfa with a lister, taking off the shares and running the seed in behind the subsoiler part of the machine. The time to sow alfalfa may be any time when the ground is in good condition between the 10th of May and the 15th of July.

Having a stand of alfalfa the next question is how shall it be maintained against its enemies, the drought and the grasshoppers? It has been demonstrated in western Kansas that thoroughly discing the alfalfa field usually increases the yield of hay, while it also prevents the deposit of grasshopper eggs in the field.

Enemies. Drought is one of the worst enemies of alfalfa without irrigation, but this may be overcome to a considerable extent by cultivation after the plants are well established, and

thorough preparation of the ground before planting. After leaving the drought out of consideration, the next enemy of importance is the grasshopper. These, working in conjunction with the drought, make the planting of alfalfa a very discouraging proposition. Grasshoppers are fond of almost all kinds of green food, and alfalfa being green in summer when the native grasses are dry, the grass hoppers come to the alfalfa patches in countless millions when other food becomes dry. When the soil is left undisturbed, they breed in the fields and in such cases keep the plants eaten down throughout the season. Thoroughly stirring the soil with a disc harrow prevents the grasshoppers breeding in the field and it has to contend with only the hoppers which grow on the prairie. By using hopper dozers the number of grasshoppers may be kept down without damaging the crop. These machines can be used only in fields where the plants are but a few inches high. Poisoning by using arsenic in bran or other substance which is relished by the hoppers is often successfully used. But the most profitable method I have ever seen employed is the poultry remedy. Some people keep so many chickens and turkeys that the grasshoppers are held in check by them. In August 1901, I visited the orchard of A. E. Tabor who lives ten miles southeast of Wray, and found many trees entirely stripped of bark and leaves by the grasshoppers. I visited the same place in 1903 and found the trees and garden in a good condition. He told me that the presence of about 400 chickens and turkeys were responsible for the good condition of the trees, and also for the scarcity of grasshoppers which I noted.

Mr. B. D. Prentice and Mr. Rufus Roberts, both living near Laird P. O., both gave testimony which coincided with what I observed at the home of Mr. Tabor. Dozens of other cases of the same kind could be cited showing the same results. The main difficulty in working the poultry remedy, is that the coyotes must be kept away or they destroy the poultry.

Location. There are many locations which catch water in considerable quantities from surrounding land. These, if occupied by moderately light clay or sandy loam soils, are ideal places for sowing alfalfa to be grown without irrigation. I have seen places where from 40 to 80 acres could be found in such alocation.

Conclusion. Alfalfa growing without irrigation deserves a trial upon a larger scale than I have yet seen, and when grasshoppers are held in check sufficiently it will certainly pay. As it is, it is the only perennial forage plant which I have seen that I would plow up buffalo grass to test upon a large scale. And when large fields of it are planted, the grasshoppers will not cut such a figure as they do now when the grasshoppers from several square miles concentrate upon a few acres.

Bulletin 91. **June, 1904.**

The Agricultural Experiment Station

OF THE

Colorado Agricultural College.

POTATO FAILURES.

A SECOND REPORT.

—BY—

F. M. ROLFS.

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(3) The large, short, segmented hyphae from a sclerotium taken from a potato tuber.

(4) Large segmented hyphae from a spore culture of **Corticium vagum,** **B and C,** var. **solani** Burt. Spores caught in potato agar and transferred to potato plugs on the fourth day. Drawings made on the twelfth day. No difference can be observed in these (Nos. 3 and 4) hyphae.

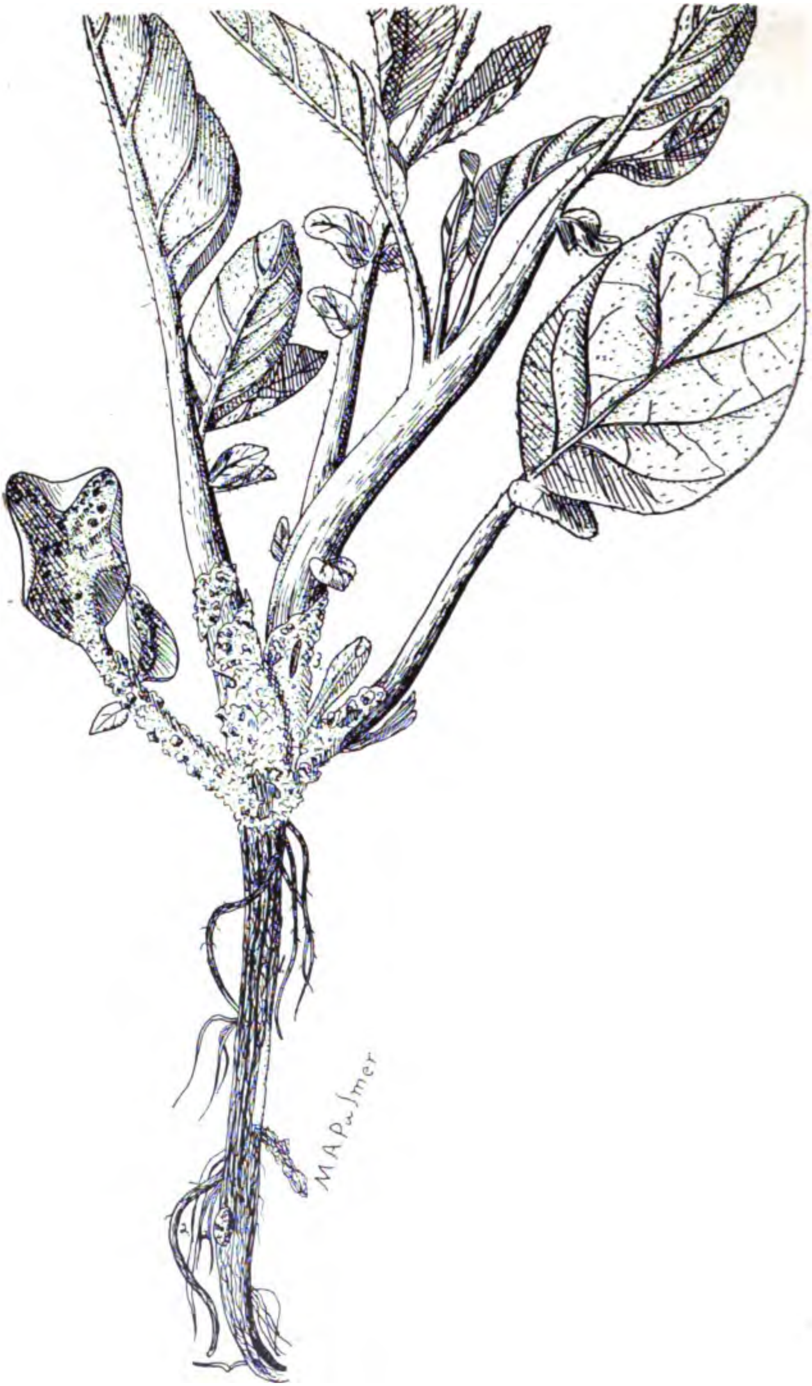

PLATE I. (1)—Black felted layer of Hyphae. (2)—Sclerotia. (3)—Corticium or fruiting layer.

Potato Failures

SECOND REPORT.

BY F. M. ROLFS, M. S.

PART I.

INTRODUCTION.

Line of Work.—Bulletin 70 of this Station gives the results of our experiments and study of *Rhizoctonia* of the potato for the year 1901. Work on this disease has been continued during the past two years. The practical value of corrosive sublimate and formalin solutions have been tested, over 120,000 pounds of seed tubers have been treated and the the influence of the treatment on the plants and crops carefully noticed. Seed selection has received considerable attention, and the influence of irrigation and cultivation on the development of the disease has also been studied. A fruiting stage of the fungus has been studied both in the laboratory and in the field.

Historical.—This disease is common to the fields of Europe, and has been reported from many localities in the United States. It is difficult to find a lot of tubers which are not more or less infected with it. Its origin is not known, however, its rhizoctonia and sclerotia stages were first reported by Kuhn, and European literature contains a number of publications on this malady. Its history in America is comparatively recent, dating back to only 1900. To my knowledge only four* publications on this potato disease have appeared in this country. Curiously enough the fruiting stage of this fungus has been overlooked, or at least never associated with the rhizoctonia and sclerotia stages, and some of our ablest workers have supposed it to be a sterile fungus; careful study, however, shows that it produces spores abundantly.

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*1 { Bulletin 186 N. Y. Cornell Exp. Station.
   { " 186 N. Y. Agr. " "
2 " 70 Colo. Agr. " "
3 and 4 Bulletins 139 and 145 Ohio Agr. Exp. Station.

DEVELOPMENT OF FUNGUS.

The fungus is truly a parasitic organism, flourishing in heavy, wet soils; and our observations during the past three years show that it produces fruit only on or near the living tissues of plants. Its development may be divided into the following stages:

The Rhizoctonia Stage.—Two forms of hyphal growth are constantly associated with the injuries resulting from this fungus —a light and a dark colored. The light form usually develops deeper in the tissues and is more actively parasitic and frequently produces a wet rot of the stem and old seed tubers, while the colored, or rhizoctonia proper develops more freely on or near the surface of the roots and tubers. The colored form is also frequently found growing in the soil some distance from the plants and is constantly associated with the fruiting stage of this fungus. (See Plate V., 1.)

The Sclerotia Stage.—The hyphæ give rise to dark irregular-shaped bodies which are made up of a mass of large, close-septate hyphæ. (See Plate V., 2.) These bodies are known as sclerotia. Experiments show that this stage is well adapted for tiding the fungus over unfavorable periods, and that it is a prominent factor in the dissemination of this disease. The sclerotia resemble closely particles of soil and are frequently mistaken for scales of dirt adhering to the tubers. When infected tubers are used for seed these Sclerotia produce hyphae which in turn injure and often kill the plants.

The Corticium Stage.—The young plants developed from seed tubers, which are more or less covered with the sclerotia stage, usually have their subterranean parts covered with a network of dark hyphæ. This dark network advances with the growth of the plant until it reaches the surface of the ground, where it changes into a grayish white fruiting layer, frequently entirely surrounding the base of the green stem and often extending up the stem for a distance of four inches. (See Plate I., 3.) The tips of the outermost hyphæ of this fruiting layer develop into basidae, which usually bear from two to four stregmata (See Plate III.), but in a few instances six have been observed. The spores are hyaline and usually ovate in form with apiculate bases; fifty spores taken just as they occurred on a green stem gave an average measurement of ten by six u. But mature spores after they had fallen measured twelve by eight u, the largest measuring fifteen by thirteen u, and the smallest nine by six u.

The hyphal characters, form of basidae, and structure of fruc-

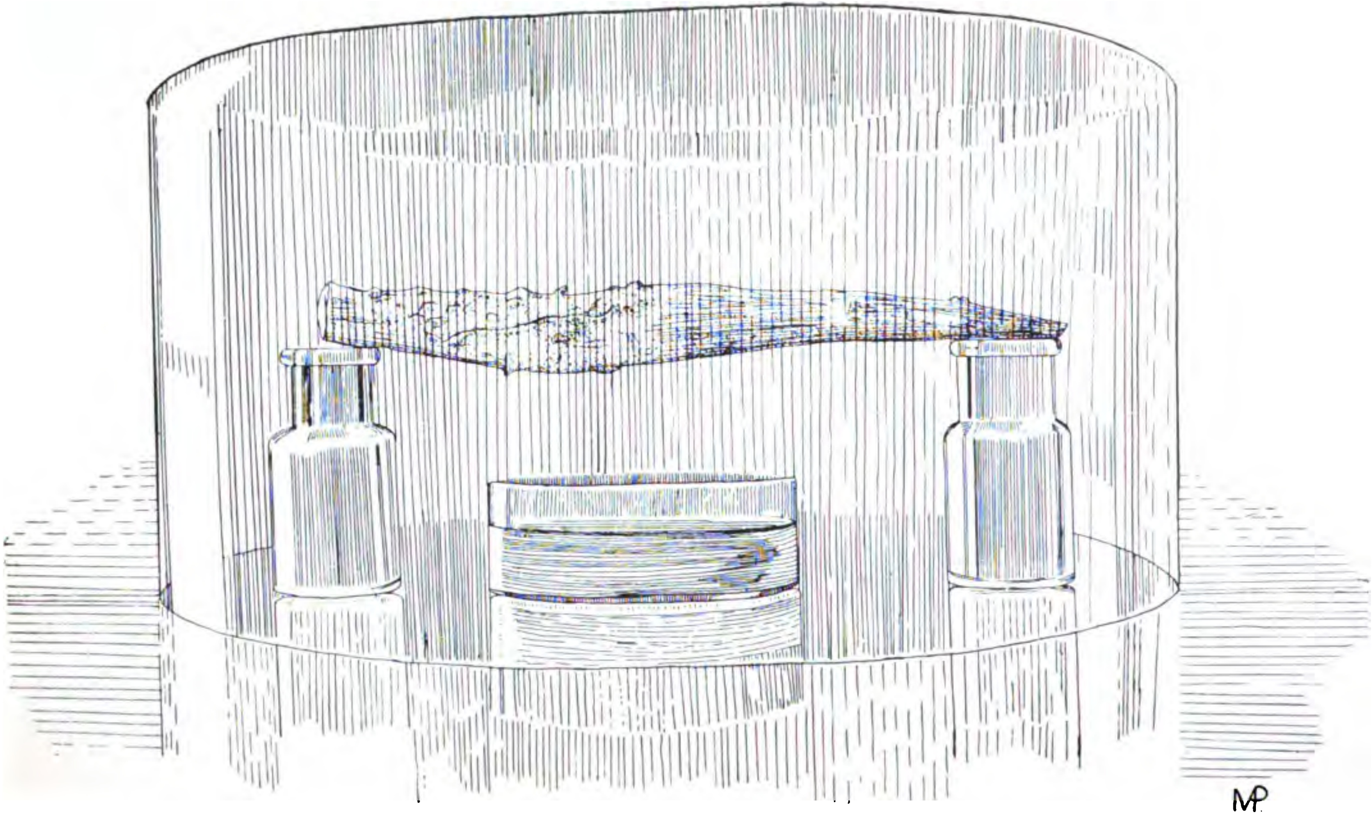

PLATE II. Arrangement for catching spores.

tification, show that it belongs to the well known species, **Corticium vagum* B. & C., but its parasitic mode of life, size and shape of spores, have been considered of sufficient distinction for a new variety and it is designated as *Corticium vagum* B. & C. var. *solani* Burt. This stage has been observed only on or near green potato plants. The fruiting layer does not adhere firmly to the stem and cracks and falls off very easily when the stem becomes too dry, consequently all traces of it usually disappear soon after the death of the plants.

From 225 pieces of stems covered with the fruiting layer placed in agar, 203 developed pure cultures of the *Rhizoctonia*; 15 *Fusarium* and 7 *Altenaria*. Cultures from this fruiting layer have been carefully watched during the past two years and they resemble in every way the pure cultures developed from the Sclerotia and pure cultures developed from hyphæ taken from a rotten tuber. All attempts in the laboratory to induce this fungus to develop spores on various culture media, have failed. However, if diseased tubers are planted in a suitable place they will produce plants on which the fruiting layer grows and develops spores abundantly.

The spores fall as soon as they are mature, consequently it is difficult to obtain cultures by the usual methods. The following plan was finally devised, which has proven quite satisfactory: A stem on which the fruiting layer had developed was suspended over a petri dish containing agar. The stem and dish were then covered with a sterile bell jar. (See Plate II.)

Spores show considerable difference in their germinating power, frequently they germinate within a few hours after they fall on agar. Each spore usually pushes out one germ tube; occasionally, however, two tubes are formed. The tube as it emerges from the spore is constricted and reaches its normal size at from 10 to 15 mm. from the spore. The growth is comparatively slow during the first two days and septa are only occasionally observed. About the third day side branches develop and the septa become more noticeable. By the fifth or sixth day the hypæ have taken on many of the *Rhizoctonia* characteristics and branch freely. Sclerotia usually form on potato plugs in twelve days.

Over sixty pure cultures of *Rhizoctonia* have been obtained from the spores of the corticium stage and these cultures resemble those obtained from the sclerotia on tubers and those made from seed tubers rotted by the hyphæ of *Rhizoctonia*.

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* This fungus agrees well with the description of ***Hyponochus solani***, Prill. & Dell., but several specimens of it were sent to Dr. E. A. Burt, and after carefully examining them he has concluded that it is a variety of ***Corticium vagum*** B. & C., for which he has suggested ***Corticium vagum*** B. & C. var. ***solani***.

INJURIES.

Plant Injuries.—Young plants suffer severely from its invasions and are often completely cut off by it before they reach the surface of the ground. Its attacks on the subterranean stems may bring about an abnormal development of tubers, which is usually spoken of as "Little Potatoes," or the injuries may be of such nature as to interfere with the storage of assimilated food in the subterranean branches of the plant, thus bringing about an abnormal top development, and frequently green tubers form in the axil of the leaves. (See Bulletin 70, p. 5–7).

In an experiment with badly infested seed 32 per cent. of the plants were killed before they reached the surface of the ground; 17 per cent. of the plants that reached the surface failed to produce tubers, and only 50 per cent. of the seed planted produced plants that developed tubers large enough for No. 1's and many of these were scabby. On July 14, 55 per cent. of the living plants showed the corticium stage of this fungus. Seed selected from this lot, but free from the sclerotia stage, produced plants of which only 20 per cent. showed traces of the corticium stage. Plants in an adjoining experiment which were free from the rhizoctonia and sclerotia stages were also free from the corticium stage.

Scabbing of Tubers.—European investigation long ago attributed the pitting or scabbing of tubers to the attacks of *Rhizoctonia.* Our experiments and observations also show that its attacks on growing tubers frequently produce deep ulcers. Most of our scab is due to the attacks of this fungus. (See Bulletin 70, p. 11).

Rotting of Seed Tubers.—Observations show that seed tubers are frequently invaded by the light colored hyphæ of this fungus, which gradually turn the flesh watery and soft. If the tubers are rotted early in the season, the plants are not only cut off from their food supply before they become well established, but they also suffer more or less from the attacks of the fungus. Such plants usually do poorly and frequently die before the close of the season. Numerous attempts to produce wet rot by inoculating healthy tubers with both the sclerotia and rhizoctonia stages have failed; however, a dry rot has occasionally developed.

Five out of eight seed tubers infected with this fungus placed in sterilized sand on July 2, 1903, and examined three months later, were completely rotted by a wet rot produced by this fungus. The remaining three were also completely rotted at the end of the fourth month, while five check tubers which were free from the fungus remained sound.

Five cultures taken from the different parts of each of these

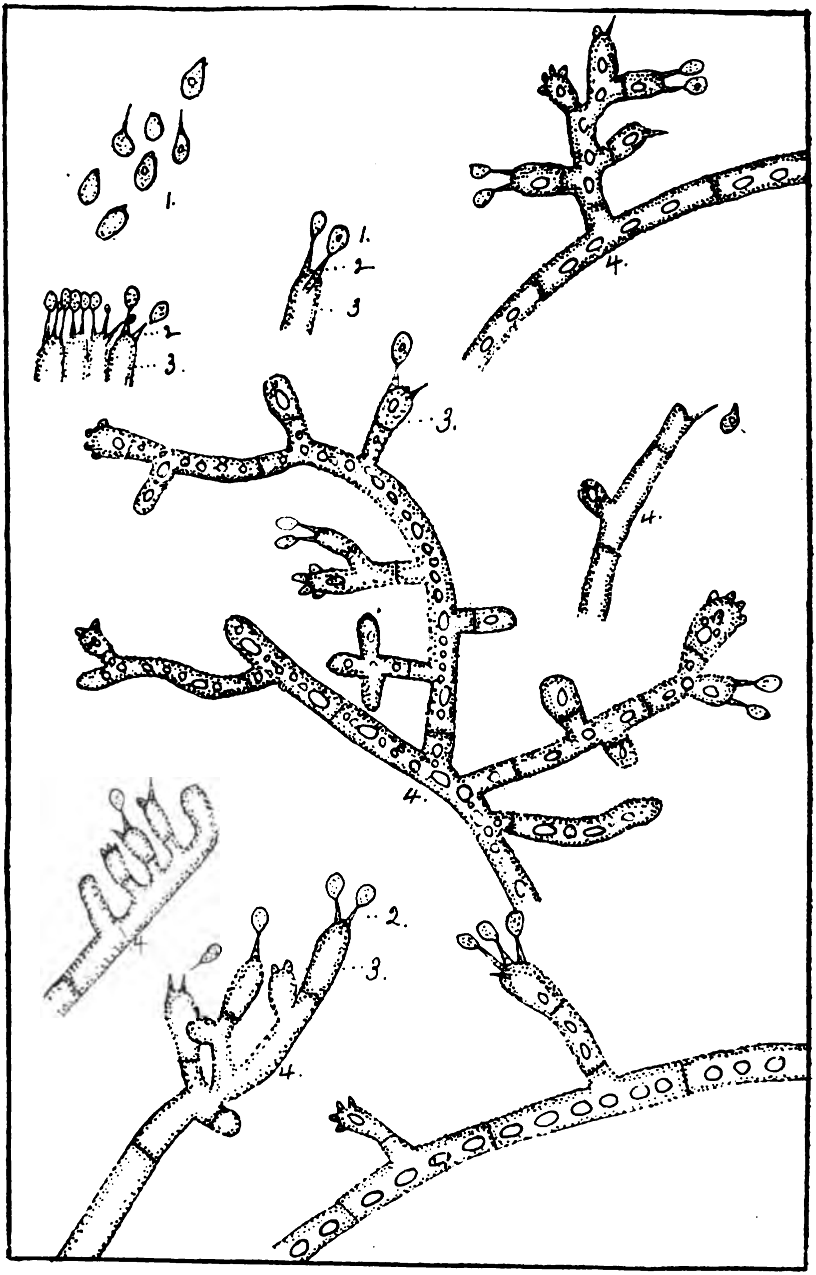

PLATE III. Hyphae, Basidia, Sterigmata and Spores of Corticium.

eight rotten tubers, making 40 cultures in all, produced pure cultures of *Rhizoctonia* in every instance.

SPREAD OF THE DISEASE.

Conditions have a marked influence on the development of this fungus. The soil and seed may be thoroughly infected and still the plants escape serious injury; on the other hand, mere traces of the disease under favorable conditions may develop and cause serious loss.

Rate of Growth at Different Temperatures.—Experiments show that pure cultures of this fungus on potato plugs and agar make very little or no growth in seven days, when kept at a temperature of about 40° F.; a slight growth at 55° F.; and a profuse growth at 72° F.

The Soil.—Some fields seem to be more favorable to the development of this fungus than others. A heavy, poorly drained soil seems to be most favorable for its development. Potatoes grown on heavy soils with good bottom drainage usually suffer less severely from this disease than those grown on poorly drained land.

It is not known how long this fungus will remain in the field when it once becomes thoroughly established, but observations of investigators show that it may live indefinitely on dead organic matter in the soil and on the roots and stems of various plants.

Influences of Heat and Moisture.—It has frequently been noticed that the corticium stage of the fungus develops freely on the surface of the ground under the potato plants and on the stems of the green plants when the ground is kept too wet during a spell of hot weather. This stage is of a light gray color and might easily be mistaken for alkali. However, some growers are quite familiar with it and know too well that its appearance on the ground under the plants indicates an over supply of water and a lack of air circulation at the base of the plants, and are well aware that if conditions are not improved the plants will be severely injured.

Laboratory work shows that a high temperature and plenty of moisture are necessary for the rapid development of this fungus. This possibly explains why extremely hot weather occasionally severely injures the plants in fields which have been thoroughly watered, while those in fields which have been sparingly watered and well cultivated remained apparently uninjured. In our experiments, when diseased plants were kept comparatively dry and well cultivated they did fairly well, but when such plants were over watered and the ground became too wet and soggy, the subterranean

parts of the plants were severely injured, and many of the tops showed marked sun scald injuries, which were followed by an invasion of *Altenaria* and many of the plants died before the close of the season.

The Seed Potato.—The sclerotia on the seed tubers is one of the principal means of disseminating this malady. It is almost impossible to find a lot of tubers entirely free from them, and some of our leading seed men send out seed tubers which are thoroughly infected. We have observed as high as 75 per cent. of infected tubers in lots offered for seed.

In storing seed careful attention ought to be given to temperature and moisture of the cellar. A comparatively dry cellar at a temperature of about 40° F. prevents the growth of this fungus, but infected tubers stored in a cellar which is warm and sufficiently damp give rise to a profuse development of both hyphae and sclerotia. A few diseased tubers in a lot of clean ones may greatly injure the seed value of the entire lot. (See Bulletin 70, p. 10).

Insect Injuries.—Frequently the larvae of insects make tunnels of considerable depths into both the stems and young tubers. The hyphae of this fungus frequently enter such wounds and may extend the injury.

Infected Plants.—This disease may be carried on the roots and stems of the various cultivated plants and weeds which grow on infected soil. (See Bulletin 70, p. 4). Infected stems and roots often find their way into barn yard manure and compost heaps; thus the manure may become the source of general infection to clean fields. Infected potato stems are frequently left scattered in the field after harvest; these are blown about by the wind and many of them finally find their way to other fields and thus become the means of general infection to new fields.

REMEDIAL MEASURES.

The Soil.—When a field has once become thoroughly infected with this fungus, it is cheaper to put it in other crops for at least three years. Evidence indicates that root crops should be avoided; cereals which are probably not attacked by the fungus should be sown on infected ground and all weeds should be kept down. Comparatively dry and loose soils, especially if they have a gravelly sub-soil, are less favorable for the development of the fungus than heavy soils. Losses from this disease are often lessened by giving careful attention to the physical condition of the soil.

Cultivation.—Too much care cannot be given to the preparation of the soil. Plowing under a green crop on infected ground from seven to eight inches deep just before planting gives good

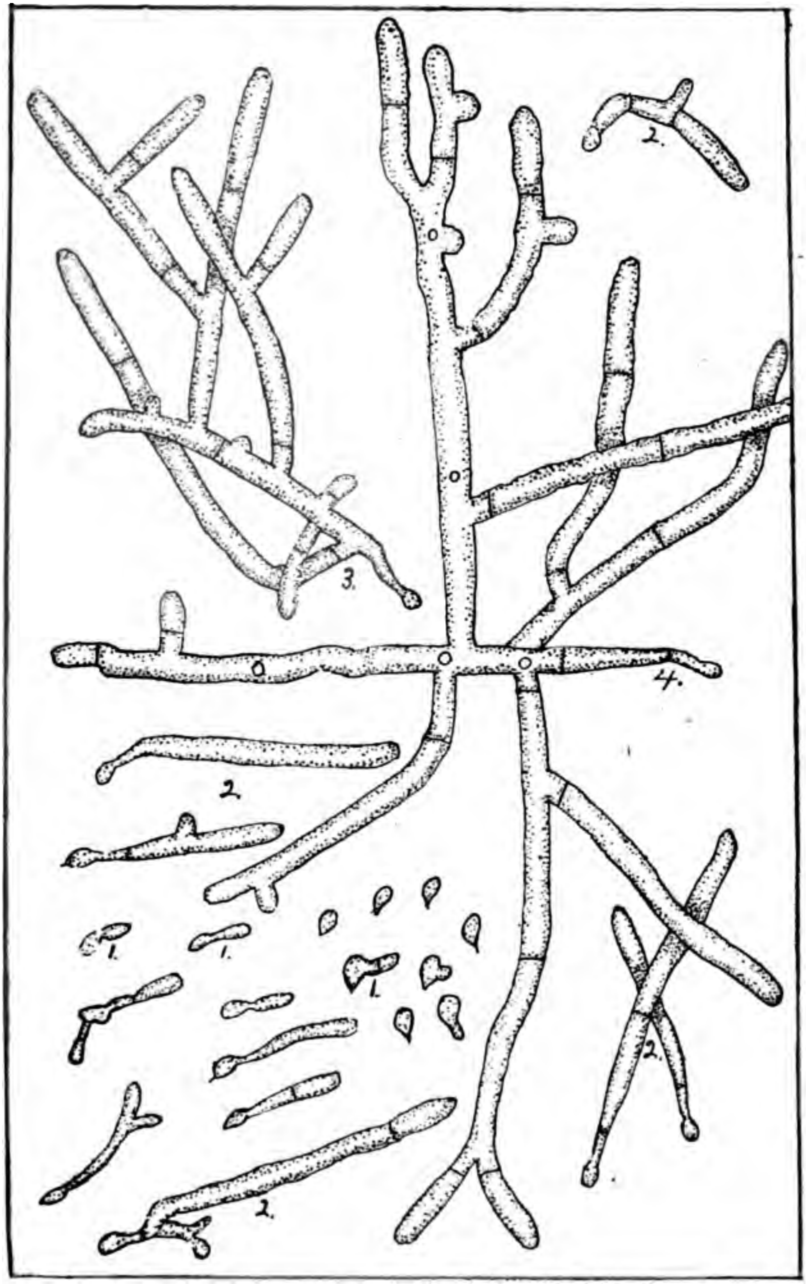

PLATE IV. (1)—Spores Germinating. (2)—Growth of Hyphae in two days (3)—Growth in three days. (4)—Growth in five days.

results. The ground ought to be thoroughly pulverized before planting. After the seed is planted great care should be exercised to prevent the soil from forming a crust. The potato plant does best in a well aerated soil. The crust not only tends to weaken the plant by cutting off its air supply, but it also frequently delays the shoots in reaching the surface of the ground; and if such plants are infected with this disease they suffer severely and are frequently killed before they reach the surface of the ground. (See Bulletin 70, p. 6). Even after the plants are up and well-established the formation of crust on the soil ought to be carefully guarded against, since it seems to furnish better conditions for the development of this disease. Observations indicate that fields which are sparingly watered and thoroughly cultivated suffer less from this fungus and the tubers are much freer from scabs.

The Runs.—Deep runs are better than shallow ones, since they give better circulation of air at the base of the plants, and they also enable the grower to supply the roots with an abundance of moisture, while the soil near the surface, where the tubers form, can be kept comparatively dry and thus avoid conditions which favor the rapid development of this fungus.

Late Planting.—Late planting frequently gives better results than early planting. This may possibly be due to the wet weather early in the spring which makes the conditions favorable for the growth of the fungus. Later the weather becomes settled and the ground can be kept well cultivated and the moisture of the soil is more easily controlled. A loose, open soil favors the growth of the potato plant and seems to check the rapid development of this disease.

Old Stems.—Infected potato and weed stems are often left scattered about in the field after harvest, and these are blown about by the wind and many of them are lodged in irrigating ditches, where they usually remain until the following summer, and as soon as the fields are irrigated, many of the stems are carried by the water into new fields and thus may become the principal means of infection. The burning of all vines and weeds after harvest is an excellent practice.

The Seed Potato.—A careful study of seed potatoes shows that it is almost impossible to find a lot of seed of which at least a few are not more or less infected with this disease. Observations indicate that seed tubers are usually the principal means of spreading this disease. (See Bulletin 70, p. 9). Too much care cannot be given to seed selection.

Tubers keep best in a dry, well ventilated dugout which is kept at about 40° F. Seed tubers ought to be stored in compara-

tively small lots and kept at as even a temperature as possible. Spreading the tubers on the cellar floor where they are exposed to the light and air five or six weeks before planting is a good practice. This treatment usually produces strong, hard sprouts after planting, which develop rapidly and are better able to resist the attacks of fungi.

Developing a Disease Resistant Variety.—Different varieties vary greatly in their suceptibility to disease when grown under the same conditions. Even plants of the same variety often show considerable difference in their power to overcome disease. It is possible that by crossing plants which show marked disease-resisting power, a desirable variety might be originated, and later be gradually improved by constantly selecting seed tubers from the plants which show the greatest disease-resisting power.

Seed Selection.—Prof. *Bolley's work on potatoes indicates that small tubers from a vine which produced mostly large tubers of desirable form and size, have greater seed value than large, poorly shaped tubers from a strain of potatoes which habitually produced small tubers. His experiments also indicate that when pieces of equal weight from small and large tubers of the same vine were planted, there was not sufficient difference in the yield to be noticeable under farm conditions, providing all tubers were normally mature. Our experiments and observations agree quite closely with those made by Prof. Bolley, but it has been observed that elongated and ill shaped tubers are usually developed on diseased vines.

Carefully selecting smooth, round tubers and rejecting all those showing any signs of infection, gave excellent results. In selecting tubers for seed, the disease-resisting power of the plant should also receive careful consideration. Diseased plants are not only apt to produce abnormally developed tubers, but the tubers ars also usually infected. Such seed often produces weak plants, which frequently suffer severely from the attacks of fungi. *Success or failure depends much on the quality oj seed tubers used.*

No commercial grower can afford to use seed without knowing something of its past history. Those who "import seed" will find it cheaper in the end to pay more for seed and buy only from men who are known to give careful attention to the quality of their seed.

Some of our most successful growers have obtained good results from carefully selecting home grown seed just before or at digging time. This practice requires some ability and involves a little extra expense. As stated before, the size of the seed tuber

* N. D. Agr. Exp., Bulletin 30.

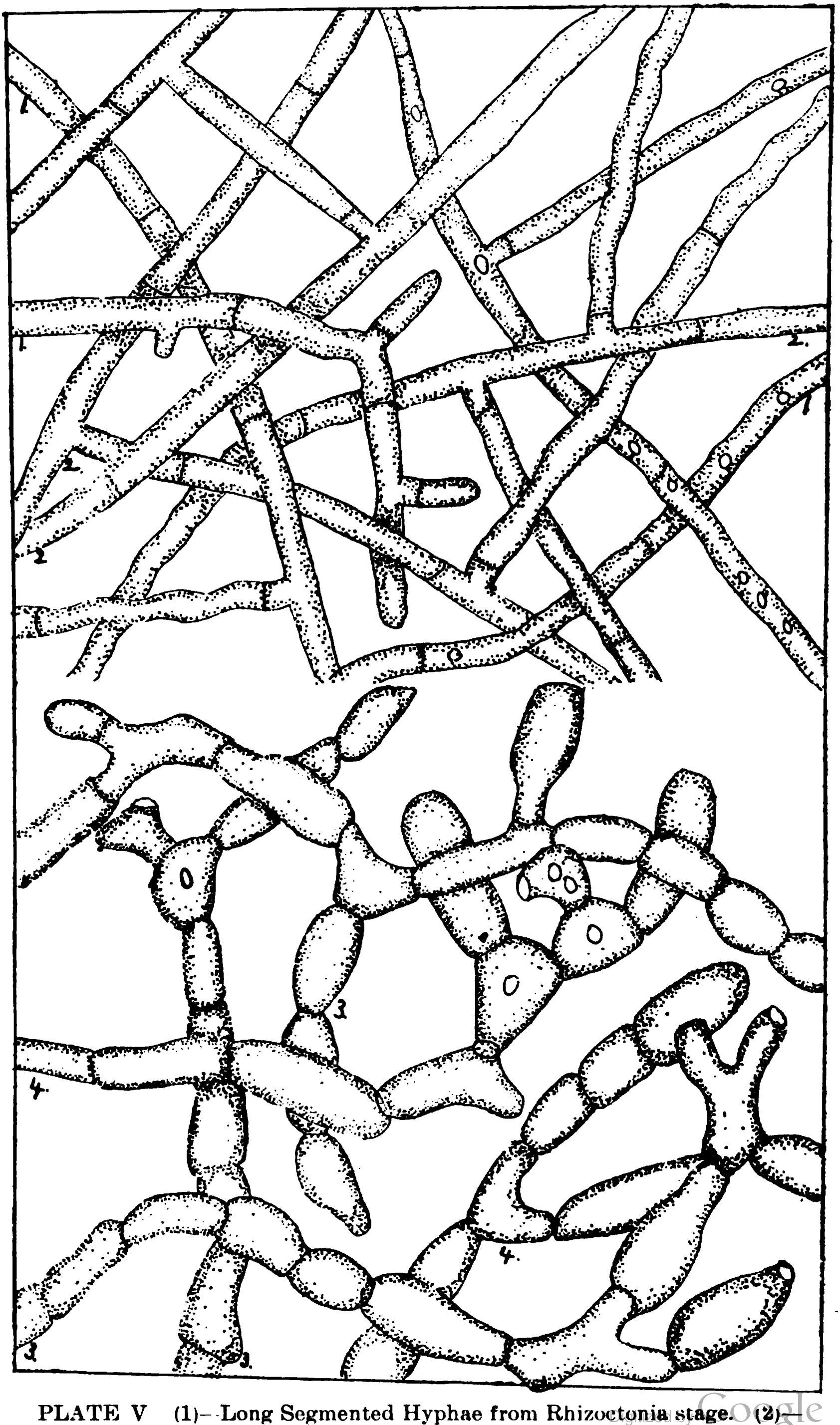

PLATE V (1)—Long Segmented Hyphae from Rhizoctonia stage. (2)—Large, Short Segmented Hyphae from a Sclerotia.

does not necessarily indicate its seed value, and unless the selecting is done in the field, the test will usually be in favor of the larger seed, since No. 2's are most likely to have a poor form and come from vines which produced mostly small tubers.

Another method which gives evidence of considerable practical value is to set aside each year five or ten acres of land for the growing of seed potatoes. The soil of such tract ought to be fertile and free from the various diseases which attack the potato plant. The tubers used in planting the seed tract are carefully selected each year from the seed plat of the previous year. The surplus seed is used for planting the general crop and in this way a strain of pedigree potatoes is gradually developed.

Corrosive Sublimate and Formalin Treatments.—The practical value of these solutions has been carefully tested. Our experiments indicate that these treatments may prevent the scabbing of tubers and improve the appearance of the crop, but usually they cut down the total yield per acre when the treated seed is planted on infected ground. However, the corrosive sublimate treatment gave marked gains when the treated seed was planted on new ground and the per centage of infected tubers in the crop was much lower. Formalin gave less favorable results, is more expensive, and weakens when exposed to the air; consequently it is difficult to keep the solution at standard strength when the dipping is done on a large scale.

Sulphur.—Thoroughly covering infected seed with sulphur at planting time apparently had very little influence on the growth of this fungus. The plants were more or less injured by the fungus, and the crop of tubers was thoroughly infected with it.

Lime.—Using lime at the rate of 3,000 pounds to the acre did not apparently check the development of this fungus. The plants did poorly, and the crop of tubers was also thoroughly infected with the fungus.

CONCLUSION.

The corticium or fruiting stage of this fungus develops freely on the green stems of the infected plants. However, it is evident that the sclerotia which are so common on the stems and tubers are also prominent factors in disseminating this disease.

Experiments indicate that treating infected seed with the standard formalin solution usually improves the appearance of the crop, but apparently weakens the plants and is apt to be the means of cutting down the total yield of tubers per acre.

The corrosive sublimate solution improved the appearance of the crop and gave marked gains when the treated seed was planted on new land. A weak solution, one ounce to ten gallons of water, gave better results than the standard when the seed was dipped in sacks and planted on old potato land.

Liming the soil at the rate of 3,000 pounds to an acre apparently did not check the disease.

Thoroughly covering the seed with sulphur also gave negative results.

The burning of all vines and weed stems as soon as the crop is harvested is an excellent practice.

Carefully selecting clean, smooth, round seed from a lot of tubers comparatively free from disease gave excellent results.

The shape and appearance of tubers give a hint as to their seed value, but their crop record and care of tubers after they are harvested are also important factors to be considered in selecting seed. Cull seed is a poor investment for a commercial grower at any price.

Spreading the seed tubers on a root house floor, where they were dry and more or less exposed to the air and light for five or six weeks before planting gave good results.

Seed tubers keep best when stored in small lots in comparatively dry, well aerated cellars which are kept at a temperature of about 40° F.

Good seed is one of the essential factors in successful potato culture; still various soil conditions seem to be fully as important. This is especially true where the soil is infected with this fungus. Observations indicate that diseased plants growing in soils well supplied with plant food are usually more successful in resisting the attacks of the fungus than those growing in soils more or less deficient in their chemical composition.

Poorly aerated soils are also more favorable for the development of this fungus. Soils which have a tendency to bake or form crusts need frequent cultivation. This is especially true while the plants are young. Plants which are thoroughly cultivated and carefully irrigated are apparently better able to overcome the attacks of this fungus and the tubers are usually free from scab.

Too much attention cannot be given to watering. If the rows are too long the field ought to be divided into sections, so as to be able to apply the water more evenly, and thus prevent part of the field from becoming too wet and soggy. Apply less water and irrigate more frequently. If the ground bakes or forms a crust, cultivate the field as soon as it becomes sufficiently dry. Keep the soil well aerated if possible.

Deep runs are also usually more desirable than shallow ones, since by this means the roots can be supplied with plenty of moisture and at the same time prevent the soil where the tubers are forming from becoming too wet, and they also furnish a better circulation of air at the base of the plants, thus making the conditions less favorable for the development of this fungus.

PART II.

DETAIL OF EXPERIMENTS.

Experiment I.—During the winter of 1900, Mr. J. G. Coy of Fort Collins, called our attention to the peculiar shape of the potato tubers grown on his place during the previous summer, apparently a mixture of Rose Seedling and Queen of the Valley. Many of the tubers were long and pointed, a good lot of what growers call "run out seed."

In the spring of 1901, seed was carefully selected from the No. 2's of the above lot, all diseased and "run out" tubers were rejected, and the seed was treated with corrosive sublimate.

The plants came up nicely but most of them blighted badly and were killed two weeks before frost. The field yielded 150 sacks of tubers per acre, and the tubers were much better than those harvested in 1900. Nine hundred and eighty pounds of the No. 2's of this crop were used as seed in the experiments of 1902. All tubers were carefully sorted and washed. The diseased and badly "run out" tubers were placed in the poor lot and are known as cull seed. There were 254 pounds of poor and 796 pounds of good seed. All the culls and 434 pounds of the better seed were treated with a solution of 8 oz. of formalin to 15 gallons of water.

The field selected for these experiments is located on the river bottom just east of town, the soil is of a black sandy loam. The field was plowed in early spring, and the seed was planted on April 25th. The rows were placed 36 inches apart and the pieces were placed at intervals of about 15 inches in the row and 4 inches deep.

The plants came up uniformly, and those of Plats IV and VI were sprayed five times. The ground was kept in almost perfect condition and the plants looked unusually promising until about July 27th, when the field was thoroughly water. From this time on the soil was compact and soggy, making the condition favorable for the development of Corticium. The roots of many of the plants were killed. The leaves and stems soon showed marked signs of sun scald. These injuries were soon followed by an attack of Altenaria, which resulted in the complete destruction of all the unsprayed plants by August 18th. The sprayed plants fared a little better, but they, too, were severely injured and were all dead and dry by August 25th. There were very few, if any, pointed tubers found in selected seed lots. In this experiment a sack of potatoes is estimated at 100 pounds.

Plat I Check—The seed of this lot was sorted with the greatest care. All diseased and injured tubers were rejected. Those which were long and pointed, or showed signs of "running out" were also rejected. The ground was quite dry at planting time, yet the plants were not long delayed in reaching the surface of the ground. This lot gave a yield of 212 sacks per acre. No "run out" tubers were observed in this plat at harvest time.

Plat II—The seed in this experiment was selected with the same care as that of the preceding plat. But it was treated in a solution of formalin on April 18th and planted on April 23rd. These plants reached the surface of the ground on time. This plat occupied the lowest part of the field; consequently the subterranean parts of these plants suffered more from the invasion of Corticium than those of the preceding plat. These plants were also the first to blight. This plat gave a return of 185 sacks per acre, making a yield of 26 pounds of tubers for every pound of seed planted,—a loss of 12%. No "run out" tubers were found in this plat at digging time.

Plat III—The culls taken from the two preceding lots were used in this plat. It was treated in a solution of formalin on April 18th and planted on April 23rd. The plat was also located on low ground, and these plants were the first to blight. An average yield of 130 sacks per acre was obtained from this plat—18 pounds of tubers for every pound of seed tubers planted—a loss of 39%. Many long and pointed tubers were taken from this plat.

Check Plat IV—The seed of this lot was sorted with the greatest of care. All diseased and injured tubers were rejected. The plants were sprayed five times with Bordeaux mixture. This experiment gave a return of 254 sacks per acre,—a return of 36 pounds of tubers for every pound of seed planted, making a gain of 40 sacks per acre from spraying. No "run out" tubers found in this lot at harvest time.

Plat V—This seed was also carefully selected and treated in a formalin solution on April 18th and planted on April 23rd. The plants reached the surface of the ground about the same time as check plants, and they were sprayed five times with Bordeaux mixture. This plat was located on the highest part of the field, consequently some of the plants suffered more or less for moisture. This plat gave a return of 193 sacks per acre,—a return of 27 pounds of tubers for every pound of seed tubers planted, making a loss of 24%. No "run out" tubers were taken from this crop. Spraying increased this yield 8 sacks per acre.

Plat VI—This seed was the last of the culls taken from the preceding lots. It was treated in a formalin solution on April 18th and planted on April 23rd. The plants came up irregularly, and many of them blighted early in spite of the fact that they were carefully sprayed five times. This plat gave a yield of 161 sacks per acre,—a return of 23 pounds of tubers for every pound of seed planted, a loss of 36%. Many "run out" tubers were taken from this crop. Spraying increased their yield 31 sacks per acre.

Results.—1. In the three experiments where the plants were sprayed five times with Bordeaux mixture, gains of 20%, 5% and 25% respectively were obtained.

2. Dipping clean, slected seed in formalin gave a loss of 12% in the first experiment and 23% in the second.

3. Cull treated seed compared with good treated seed gave a loss of 55 sacks per acre in the first experiment and 32 sacks in the second.

TABLE I., SHOWING RESULTS OF EXPERIMENT NO. I.

Plat No.	TREATMENT.	Number pounds of Seed Tubers Planted	Number pounds of Tubers Harvested	Pounds Harvested from every pound of Tubers Planted	Loss from Dipping	Number of Sacks per Acre
I.	Check	152	4605	30.29		212
II.	Dipped in Formalin Solution	217	5725	26.38	12%	185
III.	Cull Seed Dipped in Formalin Solution	64	1185	18.5	39%	130
IV.	Check, Plants Sprayed 5 Times	140	5070	36.22		254
V.	Seed Dipped in Formalin Solution, plants sprayed 5 times	217	5985	27.58	24%	193
VI.	Cull Seed Dipped in Formalin Solution, plants sprayed 5 times	190	4380	23.05	36%	161

Experiment II—The experiments given in this table were made by C. H. Bliss on old potato ground in 1902. It represents the results of experiments carefully conducted on an extensive scale, to test the practical value of these seed treatments. Great care was exercised to have the soil, watering and cultivation as nearly the same as possible. A short rotation of wheat, alfalfa and potatoes has been practiced on this place. The standard formalin treatment was used in the first three of these experiments. A weak solution of corrosive sublimate in the fourth, and a strong solution of corrosive sublimate in the last. All the treated seed was dipped in sacks.

Experiments I and III gave a loss of 11 and 10% respectively, while Experiment II gave a gain of only 3%. The weak solution of corrosive sub-

limate gave no result in one case, while in the other it gave a gain of 16%. A strong solution, on the other hand, gave a loss of 21%.

Results.—1. These experiments indicate that formalin has no marked value when the treated seed is planted on old potato ground.

2. A weak solution of corrosive sublimate has a slight value, but a strong solution is injurious when the treated seed is planted on old potato land.

TABLE II., SHOWING RESULTS OF EXPERIMENT NO. II.

Plat Number	VARIETY	TREATMENT	Number of Rows	Total Number of Sacks	Number of Sacks to the Row	Per cent of gain or loss.
I.	Pearl	Check	5	45	9	
		Formalin	6	48	8	11% loss
II.	Pearl	Check	3	24½	8	
		Formalin	4	33	8¼	3% gain
III.	Pearl	Check	4	40	10	
		Formalin	4	36½	9	10% loss
IV.	Rural New Yorkers	Check	6	40	6⅔	
		Corrosive Sublimate, weak solution	8	62	7¾	16% gain
		Corrosive Sublimate, weak solution	4	26½	6⅝	Neither gain or loss
V.	Rural New Yorkers	Check	4	27	6¾	
		Corrosive Sublimate, strong solution	4	21½	5¼	22% loss

Experiment III—These experiments were conducted by C. H. Bliss in 1902; they were also made to test the practical value of treating seed when such seed is planted on old potato ground. Home grown Rural New Yorker seed was used in this experiment. A short rotation of potatoes, wheat and alfalfa has been practiced on this place. A fair crop of alfalfa was plowed under in the spring before planting. The ground was plowed about nine inches deep and the seed was planted four inches deep on May 22. The cultivations and irrigations were the same in all the plats. The runs were made about eight inches deep.

This was an exceptionally poor season for this section, and the returns given in this table are considerably below an average crop. A sack of tubers is estimated at 100 pounds.

Plat 1 Check—The seed in this plat was rough and more or less covered with sclerotia of Corticium. This plat occupied slightly the best soil. The plants all suffered some from the attack of this fungus. Six hundred pounds of seed gave a return of 8,270 pounds of tubers. The tubers were rough and of a poor quality.

Plat II—The seed of this plat was the same as that used in check. It was treated in a solution of one ounce of corrosive sublimate to 8 gallons of water, 1½ hours on May 15th and planted on May 22nd. The plants were backward from the start and never fully overtook the check plants. All plants were more or less diseased, and the quality of the tubers was no better than those of the check plat. Six hundred pounds of seed gave a return of 6,545 pounds of tubers, making a yield of about 11 pounds of tubers for every pound of seed planted—a loss of 20%.

Plat III—All the seed in this plat was free from sclerotia; however, most of the tubers were more or less covered with hyphae. The plants

reached the surface of the ground about the same time as those of the check plat. They all suffered some from this disease, and the crop was of a poor quality and many of the tubers were covered with sclerotia. Six hundred pounds of seed gave a return of 7,555 pounds of tubers for every pound of seed planted, a loss of about 8%.

Results.—1. Diseased seed treated with the standard corrosive sublimate solution and planted on old potato ground gave a loss of 20%.

2. Seed free from the sclerotia stage, but more or less covered with the rhizoctonia stage, planted on old ground, gave a loss of 8%.

TABLE III., SHOWING RESULTS OF EXPERIMENT NO. III.

Plat Number	TREATMENT	Number Pounds of Seed Planted	Pounds of Potatoes Harvested	Yield in Pounds for every Pound of Seed Planted	Per Cent. of Loss	Number of Rows to the Acre
	Check	600	8270	13.75		5
	Treated	600	6545	10.9	20%	5
	Selected Seed	600	7555	12.59	8%	5

Experiment IV—The following experiments were made by S. A. Bradfield in 1902 to test the value of treating diseased seed with corrosive sublimate when such seed is planted on old potato ground. A short rotation of wheat, alfalfa and potatoes has been practiced on this place for a number of years. A fair crop of alfalfa was plowed under in the spring before planting. The soil in this field is of a black loam, slightly sandy; it slopes gradually to the south and east. The runs between the rows were from seven to eight inches deep, which made it possible by carefully watering to supply the roots with plenty of moisture, and at the same time to prevent the soil in which the tubers developed from becoming too wet and soggy. Second year's Divide Pearl seed was used in these experiments.

Plat I Check—This plat was located on lower and in slightly better soil than the other two experiments. All the tubers were more or less covered with sclerotia of Corticium. The seed was planted about May 18th. Five hundred and six pounds of seed yielded 11,553 pounds of tubers, giving a return of 23 pounds of tubers for every pound of seed planted. These tubers were smaller, and were more or less covered with sclerotia. Careful observation also showed that this lot also contained the most scabby tubers.

Plat II—The seed of this plat was more or less covered with sclerotia, but they were treated with a solution of one ounce of corrosive sublimate to eight gallons of water for 1½ hours nine days before they were planted. These plants were five days late in reaching the surface of the ground. A careful examination of plants from various parts of this plat showed plainly that most of the plants had their subterranean parts covered with the hyphae of this fungus. Six hundred pounds of seed gave a return of 11,161 pounds of tubers, making 18½ pounds of potatoes for every pound of seed planted, but the tubers were cleaner, larger and better in every way than those in the Check plat.

Plat III—This seed was taken from the same lot of tubers as those in the other experiments. All tubers having sclerotia on them were rejected, but many of the tubers were scabby and all of them were more or less covered with the hyphae. This experiment occupied the highest and probably the poorest ground. Five hundred and four pounds of seed gave a return of 10,574 pounds, making 21 pounds of tubers for every pound of seed planted. A loss of 9%. However, the tubers were larger and cleaner than those of the Check plat.

Results.—1. Diseased seed treated with corrosive sublimate gave a loss of 20%.

2. Seed free from the sclerotia stage, but more or less covered with the rhizoctonia stage gave a loss of 9%. The tubers were larger and of a better quality.

TABLE IV., SHOWING RESULT OF EXPERIMENT NO. IV.

Plat Number	TREATMENT.	Number Pounds of Seed Tubers Planted	Total Number of Pounds of Tubers Harvested	Yield in Pounds for every Pound of Seed Tubers Planted	Loss	Yield in Sacks per Acre
I	Check	506	11553	23		137
II.	Seed Treated with 1 oz. Corrosive Sublimate to 8 gallons of water	600	11161	18½	20%	111
III.	Washed and all tubers containing sclerotia rejected	504	10574	21	9%	126

Experiment V—The experiments in the following table were conducted by E. R. Bliss in 1902. They were made on old potato ground, but the field had been in alfalfa during the previous two years, and a fair crop of alfalfa was plowed under in the spring before planting. The seed was treated with formalin on May 20 and planted about May 24. The rows compared were of the same length, and the cultivation and irrigation in all the experiments were the same. A sack of tubers in these experiments is estimated at 100 pounds.

Lot 1, Plat I Check—Sixty pounds to the row of Prolific seed from the Divide were used in this plat. The soil in this plat was slightly better than that of the treated seed plat; otherwise the conditions were the same; only a few deceased plants were observed in this plat. This plat gave a return of 26 pounds of tubers for every pound of seed planted, a yield of 158 sacks per acre.

Plat II—Sixty pounds to the row of Prolific Divide seed were use in this plat. It was dipped in sacks in a solution of eight ounces of formalin to fifteen gallons of water for two hours. No diseased plants were observed in this plat and the crop of tubers was clean and smooth. Twenty-four pounds of seed were harvested for every pound of seed planted, making a return of 144 sacks per acre—a loss of 10%.

Lot II. Plat I Check—Fifty pounds to the row of Pearl first year's Wisconsin seed were used in this plat. It was planted May 30th. The soil, cultivations and irrigations were as nearly the same in these plats as it was possible to have them. Thirty-three pounds of tubers were harvested for every pound of seed planted—a return of 199 sacks per acre.

Plat II—Fifty pounds to the row of first year's Wisconsin Pearl were planted in this plat, which had been treated in sacks with a solution of eight ounces of formalin to sixteen gallons of water for two hours. One thousand two hundred pounds of this seed were planted on May 24th, and the remaining 2,640 pounds on May 26th. No diseased plants were observed in this plat and the tubers were clean, smooth and free from disease. One pound of seed gave a return of 30 pounds of tubers—a yield of 179 sacks per acre, making a loss of 10%.

Lot III. Plat I Check—Forty pounds to the row of second year Wisconsin Pearl seed were used in this plat. There were some deceased plants observed in this plat, but on the whole the plants were strong and vigorous. One pound of seed gave a return of 25 pounds of tubers—a yield of about 150 sacks per acre.

Plat II—Forty pounds to the row of second year Wisconsin Pearl seed were used in this lot. It was treated in sacks with a solution of eight ounces

of formalin to sixteen gallons of water for two hours. Each pound of seed gave a return of 21 pounds of tubers, making a yield of about 128 sacks of tubers per acre—a loss of 14⅛%.

Results.—1. Divide Prolific seed treated with standard formalin solution gave a loss of 10%.

2. First year's Wisconsin Pearl seed treated in standard formalin solution gave a loss of 10%.

3. Second year's Wisconsin Pearl seed treated in a standard formalin solution gave a loss of 14%.

TABLE V., SHOWING RESULTS OF EXPERIMENT NO. V.

Variety, Where Raised	TREATMENT	Number Pounds of Seed Tubers to row	Number Pounds of Tubers Harvested from a Row	Number of Rows in Acre	Yield in Pounds for every Pound of Seed Planted	Gain or Loss	Number of Sacks per Acre
Prolific, Divide Seed	Check	60	1580	10	26.33		158
	Formalin Treatment	60	1440	10	24.00	10% Loss	144
Pearl, Wisconsin Seed First Year	Check	50	1660	12	33.20		199
	Formalin Treatment	50	1490	12	29.80	10% Loss	179
Pearl, Wisconsin Seed Second Year	Check	40	990	15	24.75		149
	Formalin Treatment	40	850	15	21.25	14⅛% Loss	128

Experiment VI—The experiments given in the following table were made by the Agricultural Department in 1901. Rose Seedling seed was used which had been stored in a damp cellar. Many of the tubers were more or less covered with Corticium hyphae. This seed was removed from the cellar about June 1st, and placed in a dry room until June 12th, which thoroughly dried all the tubers. The field on which this seed was planted has been under cultivation for a number of years. It was plowed late in the spring and the seed was planted on June 12th. None of the plats were watered, still nearly all of the plants remained green until killed by frost.

Plat I Check—These plants were more or less diseased, but most of them looked strong and healthy until killed by frost. The fruiting stage of this fungus was observed on many of the plants. One hundred and forty pounds of seed gave a return of 767 pounds of tubers, a yield of 5 33-100 pounds of tubers for every pound of seed planted, or about 32 sacks per acre.

Plat II—This seed was of the same grade as the check lot. It was treated with corrosive sublimate one week before it was planted. These plants were a little slow in reaching the surface of the ground, but they soon looked fully as strong and vigorous as the checks. Very few scabby or diseased tubers were found in this lot. One hundred and one pounds of seed produced 539 pounds of tubers, a return of 5 17-50 pounds of tubers for every pound of seed planted, making about 32 sacks per acre, no gain over check.

Plat III—This seed was also of the same grade as the check lot, but it was treated with formalin a week before it was planted. The plants came up fully as well as those of the check plat and apparently were as strong and vigorous. One hundred and five pounds of seed gave a return of 466 pounds of smooth clean tubers, a yield of 4 11-25 pounds of tubers for every pound of seed planted, making a loss of 17%. About 27 sacks of tubers to the acre.

Plat IV—This seed was carefully selected, rejecting all tubers containing sclerotia, but all of the seed tubers were more or less covered with the hyphae. Eighty pounds of seed gave a return of 475 pounds of tubers, a

return of six pounds of tubers for every pound of seed planted. The tubers were all more or less covered with the sclerotia, but were not so badly scabbed as the tubers of the check plant. This plat gave a return of 36 sacks per acre.

Plat V—This was the poorest lot of seed, about 30% of the tubers failing to produce plants which reached the surface of the ground. The plants did poorly and many of those that reached the surface of the ground died before the close of the season. Thirty-five pounds of seed gave a return of 107 pounds of small, rough tubers,—a yield of a little over three pounds of tubers for every pound of seed planted, making a loss of 42%, a return of about 19 sacks per acre.

Results.—1. Success or failure in potato culture in this section of the state depends much upon the water supply.

2. The corrosive sublimate seed treatment gave no marked results when the treated seed was plantd on land which had been under cultivation for a number of years.

3. The formalin seed treatment gave a loss of 17% when such seed was planted on ground which had been under cultivation for a number of years.

4. Carefully selecting seed, free from sclerotia stage, gave a gain of 11%.

TABLE VI., SHOWING RESULTS OF EXPERIMENT NO. VI.

Plat Number	TREATMENT.	Number Pounds of Seed Potatoes Planted	Total Number of Tubers Harvested	Yield in Pounds for every Pound of Seed Tubers Planted	Gain or Loss	Yield in Sacks per Acre
I.	Check	140	767.80	5.33		32
II.	Treated with Corrosive Sublimate	101	539.50	5.34		32
III.	Treated with Formalin	105	466.50	4.44	17% Loss	27
IV.	Seed free from Sclerotia, but more or less covered with hyphae	80	475.50	5.94	11% Gain	36
V.	Cull Seed	35	107.70	3.08	42% Loss	19

Experiment VII—Rose Seedling seed was used in this experiment which was raised by the Agricultural Department from tubers bought on the market in the spring of 1901. Many of the tubers were covered with the hyphae and sclerotia of Corticium. This seed was planted on an old berry plantation, located on a knoll sloping toward the south and west. The soil is of a sandy loam, and has been well cultivated and manured during the past five years. It was plowed 8 inches deep in early spring and planted on May 6. The rows were planted 40 inches apart, the pieces being put at intervals of about 9 inches and 5 inches deep.

The plants of this experiment were sprayed three times with Bordeaux mixture. There was very little difference in the appearance of the plants in the various plats at any time during the season. The water was low in the ditch during the later part of the summer, so this field was irrigated but twice. The plants on the higher soil suffered some from sun scald. Altenaria was also found on some of the plants, but it apparently developed only on those which had an injured root system. The weight of a sack of tubers is estimated at 100 pounds.

Plat I Check—This seed was stored in the dugout all winter. Many of the tubers were more or less covered with the sclerotia of Corticium. The tubers were cut on May 5 and planted on the following day. These plants did quite well, but a number of diseased plants were observed in this plat

during the summer, and many diseased tubers were found in this plat at harvest time. It gave an average yield of 147 sacks of tubers per acre.

Plat II—This seed also contained many diseased tubers, but it was treated with corrosive sublimate one day before planting. The plants were five days late in reaching the surface of the ground. A few diseased plants were observed in this plat during the summer, but the tubers were clean, smooth and free from both scab and sclerotia. This plat gave a return of 213 sacks of tubers per acre, a gain of 66 sacks per acre.

Plat III—This seed was treated with corrosive sublimate on December 9th. After it became thoroughly dry it was again sacked and placed in the dugout until May 6th, when it was cut and planted. The plants were a week late in reaching the surface of the ground, but they did nicely and no diseased plants were observed in this plat. The tubers were clean, smooth and free from both scab and sclerotia. This plat gave a return of 160 sacks of tubers per acre, a gain of 13 sacks per acre over check.

Plat IV—This seed was taken from the dugout on December 9th, and treated with corrosive sublimate one hour and then placed on the floor until thoroughly dry, when it was sacked and placed in the dugout until May 5th, when it was again placed in a solution of corrosive sublimate for one hour. It was cut and planted on May 6th. The plants were 8 days late in reaching the surface of the ground. They did nicely, however, and no diseased plants were observed in this plat. The crop was clean. smooth and free from both scab and sclerotia. This plat gave a return of 143 sacks of tubers per acre, a loss of 4 sacks per acre over check.

Plat V—This seed was exposed to the light 23 days, five months before planting. It was then stored in the dugout until May 6th, when it was cut and planted. The plants reached the surface of the ground a few days in advance of those of the check plat. A number of diseased plans were observed in this plat, but no scab or sclerotia was observed on the tubers at harvest time. This seed gave a return of 196 sacks of tubers per acre, a gain of 49 sacks per acre.

Plat VI—This seed was stored in the dugout all winter. On May 5th all the stem ends were removed; otherwise the seed was treated like that of the check plat. No difference was noticed in the appearance of the plants in these two plats. Some of the tubers contained a few sclerotia at harvest time. This plat gave a return of 153 sacks of tubers per acre, a gain of 6 sacks per acre.

Results.—1. The standard corrosive sublimate treatment gave an increased yield of 45%. The tubers were larger, cleaner and better in every way.

2. Treating seed with corrosive sublimate five months before planting gave an increased yield of 9%. The tubers were also larger, cleaner and better than those of the check plat.

3. Treating the seed with a solution of corrosive sublimate, standard strength, one hour, five months before planting, and again one hour one day before planting, gave a loss of 2%, but the tubers were clean, smooth and free from disease.

4. Exposing the seed to the light 23 days five months before planting apparently increased the yield 35%.

5. Rejecting the stem end piece did not give marked results.

TABLE VII., SHOWING RESULTS OF EXPERIMENT NO. VII.

Plat Number.	TREATMENT.	Number Pounds of Seed Tubers Harvested	Total Number Pounds of Tubers Harvested	Yield in Pounds for every Pound of Tubers Planted	Gain or Loss	Yield in Sacks per Acre
I.	Check	111	1809	16.30		147
II.	Treated with Corrosive Sublimate 1 day before planting	90	2125	23.61	45% Gain	218
III.	Treated with Corrosive Sublimate 5 months before planting	109	937	17.77	9% Gain	160
IV.	Double Corrosive Sublimate Treatment	112	1783	15.90	2% Loss	143
V.	Seed Exposed to Light 28 days, 4 months before planting	104	2267	21.79	35% Gain	196
VI.	Stem End Rejected	89	1514	17.00	4% Gain	153

Experiment VIII—Rose Seedling seed was used in this experiment which was from the No. 1's of last year's experiment. It was planted on April 9th. The plants came up nicely and they were irrigated twice, still, most of them remained green until killed by frost. Some showed marked sun scald injuries early in the season, which were soon followed by early blight.

The field used in this experiment had been under cultivation for the past seven years. The soil is of a heavy clayey loam. This field has received very little manure during the past five years. The soil was too heavy for a desirable potato field.

Plat I Check—The largest tubers from last year's check plat were used for seed in this lot. Most of the plants remained green, but some of them had their subterranean parts badly injured and developed marked sun scald injuries. Three hundred and nine pounds of seed gave a return of 1,716 pounds of tubers, or 5½ pounds for every pound of seed planted.

Plat II—This seed was selected from the No. 1 of a lot which had been treated with formalin last year. They were treated with corrosive sublimate on April 30, and planted on May 9. These plants reached the surface of the ground about as soon as those of the check plat. No diseased plants were observed in this plat. Three hundred and thirty-four pounds of seed gave a return of 2,616 pounds of clean tubers, a yield of 7.8 pounds of tubers for every pound of seed planted, making a gain of 41% over check.

Plat III—This seed was selected from the No. 1's of last year's experiments. Only clean, round, smooth tubers were used. All long and all flat tubers were rejected. The soil of this plat was in a better condition than the soil of the other plats. No diseased plants were found in this plat, and the tubers were fully as clean and smooth as those of the treated lot. Two hundred and forty-six pounds of seed yielded 2,807 pounds of tubers, a return of 11½ pounds of tubers for every pound of seed planted, giving a gain of 106% over check.

Plat IV—Seed in this lot was selected from the various lots of last year's experiments. Only the long, smooth tubers were used. The plants were not so strong and vigorous as those of Plat III, but no diseased plants were observed in this plat. The tubers were all long, but only a few pointed ones were found at harvest time. One hundred and ninety-three pounds of seed gave a return of 1,283 pounds of tubers, a yield of 6½ pounds of tubers for every pound of seed planted, making a gain of 20% over check.

Plat V—This seed was selected from the No. 1's of the previous year's experiments. At least 20% of them had a few sclerotia of Corticium on them. Many diseased plants were observed in the plat and the crop was rough and

scabby. Two hundred and eighty-one pounds of seed gave a return of 1,531 pounds of tubers, a yield of 5½ pounds of tubers for every pound of seed planted, making a loss of 2%.

Plat VI—This seed was selected from the culls of last year's experiments. Only the round tubers were used. One hundred and seventy-five pounds of seed gave a return of 982 pounds of tubers, a yield of 5⅝ pounds of tubers for every pound of seed planted, an increase of 2% over check.

Results.—1. Treating diseased seed with corrosive sublimate, standard strength, increased the yield 41%.

2. Carefully selecting perfect shaped tubers gave a gain of 106% of smooth, round tubers.

3. Carefully selecting clean, long tubers gave a gain of 20%, but the tubers were all long and ill shaped.

4. Cull seed gave a loss of 2%. The tubers were rough and scabby.

5. Small, round seed gave a gain of 2% over check and the crop was fully as good in every way.

TABLE VIII., SHOWING RESULTS OF EXPERIMENT NO. VIII.

Plat Number	TREATMENT	Number Pounds of Seed Tubers Planted	Total Number of Pounds of Tubers Harvested	Yield in Pounds for every Pound of Seed Planted	Gain or Loss	Yield in Sacks per Acre
I.	Check	309	1716	5.55		39
II.	Corrosive Sublimate, 1 oz. to 8 gallons of water	334	2616	7.83	41% Gain	55
III.	Large Selected Seed	246	2807	11.41	106% Gain	80
IV.	Long Pointed Seed	193	1283	6.64	20% Gain	46
V.	Diseased Seed	281	1531	5.44	2% Loss	38
VI.	Small Round Seed	175	982	5.61	2% Gain	39

Experiment IX—These experiments were conducted in a field which had been planted in currents during the previous four years. It slopes toward the west and the soil is a heavy clay, but it has been well manured and cultivated for a number of years. It was plowed 8 inches deep in early spring and on May 6th planted with Rural New Yorker seed. These tubers were exceptionally clean. They were taken from a lot of tubers which was raised from mountain seed in 1901 by the Agricultural Department. The rows were planted 40 inches apart, the pieces being placed at intervals of 15 inches, and 5 inches deep. The plants in this experiment came up uniformly, and were all sprayed three times with Bordeaux mixture, which kept their foliage in good condition until killed by frost on the night of September 11th.

The water was unusually low in the ditch during the latter part of the season, consequently the plants in all of these plats suffered more or less from lack of moisture. All the plats were watered twice excepting Plat V, which was watered three times. The return from this plat shows plainly that if the field had been properly watered the yield would have been much larger. The plants in this experiment were carefully watched during the entire season, and we observed only a few diseased plants in these plats. The tubers were clean, smooth and free from scab.

Plat I Check—The seed in this lot was taken from the dugout on December 9th and was placed in water two hours and then placed on the floor

of the Horticultural Building until thoroughly dry, when it was sacked and placed in the dugout. On May 6th it was cut and planted. The plants came up nicely and remained strong and vigorous all the season, giving an average yield of 142 sacks per acre of clean, smooth tubers.

Plat II—This seed was treated with a solution of one ounce corrosive sublimate to eight gallons of water on December 9th. After the tubers had been soaked one hour they were placed on the floor until dry, when they were sacked and stored in the dugout. On May 5th they were again treated with corrosive sublimate for one hour and cut and planted on the following day. The plants were a little later in reaching the surface of the ground, but six weeks later they were fully as large and vigorous as those of the check plat. No diseased plants or tubers were found in this plat. This plat gave an average yield of 144 sacks per acre of clean, smooth tubers, a gain of 2 sacks per acre over check.

Plat III—The seed in this plat was taken from the dugout on December 9th, and treated two hours with a solution of eight ounces of formalin to sixteen gallons of water. The tubers were then placed on the floor until the following day, when they were sacked and placed in the dugout until May 6th, when they were cut and planted. The plants reached the surface of the ground on time, and were strong and vigorous until killed by frost. No diseased tubers were observed when the crop was harvested. This plat gave a gain of 13 sacks per acre, but this gain was probably due to seepage water from the lawn thoroughly soaking six of the rows on the night of August 3rd. These tubers were unusually good.

Plat IV—This seed was taken from the dugout on December 7th, and placed on the basement floor of the Horticultural Hall, where it was fully exposed to the light On the 30th of December it was again sacked and placed in the dugout. On May 6th it was taken out, cut and planted. These plants reached the surface of the ground possibly a little in advance of the check, but they showed no marked gain over the the check plants at any time. This plat gave an average yield of 144 sacks to the acre of clean, smooth tubers, a gain of two sacks per acre over check.

Plat V—This seed was selected and treated just the same as that of the check plat, but the plants were carefully irrigated three times. No diseased plants or tubers were taken from this plat. The plants remained green and vigorous until killed by frost. This plat gave an average yield of 197 sacks per acre of good, large tubers, a gain of 55 sacks per acre over the check.

Results.—1. Dipping clean, healthy seed tubers in a solution of corrosive sublimate, standard strength, for one hour, five months before planting, and again for one hour just before planting, apparently had no influence on the seed when such seed was planted in new ground.

2. Clean, healthy seed treated in a solution of eight ounces of formalin to sixteen gallons of water for two hours, five months before planting, gave no marked result when such seed was planted in new ground.

3. Exposing clean, healthy seed to the light 23 days, five months before planting, gave no marked results.

4. Three thorough waterings gave 38% larger returns than two waterings.

TABLE IX., SHOWING RESULTS OF EXPERIMENT NO. IX.

Plat Number	TREATMENT	Number Pounds of Seed Tubers Planted	Total Number of Pounds of Tubers Harvested	Yield in Pounds for every Pound of Seed Planted	Gain	Number of Sacks per Acre
I.	Check, irrigated two times	64	1298½	20.29		142
II.	Corrosive Sublimate, 1 hr., 12-9-01, again 5-5-02, Irrig'td. twice	105	2167	20.63		144
III.	Treated with Formalin 2 hrs. 12-9-01. Irrigated 2 times	115	2554	22.20	9%	155
IV.	Seed exposed to light 23 days. Irrigated 2 times	70	1437	20.52		144
V.	Check, Irrigated 3 times	33	988	28.11	39%	197

Experiment X—The seed in the following experiment was taken from the Rural New Yorker No. 1's of last year's experiments. It was planted on heavy, clayey ground which had been a plum orchard for a number of years, but it had been well cultivated and manured during the previous five years. The water supply in the ditch gave out early in the season and the field received but two waterings.

The ground was plowed eight inches deep in the early spring and the seed was planted five inches deep. The plants came up nicely and their foliage remained green until killed by frost.

Plat I—Check—The tubers of this lot were smooth and clean, not a scabby or diseased tuber was observed in the lot. The plants were strong and healthy. Three hundred and forty-eight pounds of seed gave a return of 3,042 pounds of clean, round tubers, a yield of 8.7 pounds of tubers for every pound of seed planted.

Plat II—The seed from which these tubers grew was treated with corrosive sublimate and this seed was also treated with corrosive sublimate. It was an evcellent lot of seed. The plants were strong and vigorous and the foliage remained perfect until killed by frost. Three hundred and sixty-three pounds of seed gave a return of 3,429 pounds of tubers; 9.44 pounds of tubers for every pound of seed planted, a gain of 8½%.

Plat III—All the long and flat tubers were rejected from this lot, only the clean, round and perfect shaped tubers were used. Two hundred and seventy pounds of seed gave a return of 3,141 pounds of tubers, a yield of 11.63 pounds of tubers for every pound of seed planted, making a gain of 33⅓% over check.

Plat IV—The tubers in this lot were taken from the No. 1's of last year's crop, but all of them were ill-shaped and more or less scabby. Two hundred and fifty pounds of seed gave a return of 1,559 pounds, a yield of 6.24 pounds of tubers for every pound of seed planted, giving a loss of 28% when compared with check.

Results.—1. Good, healthy seed treated with corrosive sublimate and planted in new soil gave a gain of 8½%.

2. Carefully selected seed gave a gain of 33⅜%.

3. Selecting all the poorest shaped, scabby and diseased seed and planting it on new ground gave a loss of 28⅛%.

4. The difference between best and poorest seed being 62%.

TABLE X., SHOWING RESULTS OF EXPERIMENT NO. X.

Plat Number	TREATMENT	Number Pounds of Seed Tubers Planted	Total Number Pounds of Tubers Harvested	Yield for Every Pound of Seed Planted	Gain or Loss	Yield in Sacks per Acre
I.	Check	348	3042	8.70		60
II.	Corrosive Sublimate, 1 oz. to 8 gals. of water	363	3429	9.44	8½% Gain	66
III.	Good Selected Seed	270	3141	11.63	33⅜% Gain	81
IV.	Poor Selected Seed—Culls	250	1559	6.24	28⅛% Loss	44

Experiment XI—These experiments were undertaken in 1903 to test the value of selecting seed and the value of treating inferior seed with corrosive sublimate solution. An exceptionally badly diseased lot of Rural New Yorker seed was secured for this test. These experiments were planted on an old plum orchard containing a heavy, clayey soil, but it had been well manured and cultivated for the past five years. The soil was plowed eight inches deep in early spring and the seed was planted four inches deep on April 9th. The plants did poorly from the first. The water was turned out of the main ditch during the fore part of the season so the field was irri-

gated but twice. The runs were only about four inches deep, making it impossible to supply the water properly.

Plat I—Check—These tubers were rough and scabby and all of them were more or less covered with the hyphae and sclerotia of Corticium. The plants came up very unevenly and 32% of this seed failed to produce plants which reached the surface of the ground, Seventeen per cent. of those that grew, developed small worthless tubers. Only 57% of the seed planted produced plants which developed large tubers, and these were scabby and of a poor quality. On July 24th the plants in this plat were carefully examined and it was observed that 55% of the plants had their main stems covered with the fruitage stage of this fungus. Three hundred and twenty-five pounds of seed gave a return of 1,240 pounds of tubers. A yield of 3⅘ pounds of tubers for every pound of seed planted. A return of 23 sacks to the acre.

Plat II—This seed, like that used in the Check plat, was scabby and more or less covered with the hyphae and sclerotia. It was treated with corrosive sublimate, standard strength, seven days before it was planted. These plants were about eight days later than those of the Check plat and they also came up very unevenly. Twenty-six per cent. of the seed failed to produce plants which reached the surface of the ground. Ten per cent. of those that grew failed to develop large tubers. Only 67% of the seed planted developed salable tubers. They were clean and quite free from scab. Fifteen per cent. of the plants in this lot showed traces of the fruiting stage. Two hundred pounds of seed gave a return of 1,080 pounds of tubers. A return of 5⅖ pounds of seed for every pound of seed planted. Giving a gain of 41% over Check, or about 32 sacks to the acre.

Plat III—This seed was carfeully selected. All tubers containing sclerotia were rejected. However, many of these were rough and scabby, and all of them were more or less covered with the hyphae. These plants also came up very unevenly. Seventeen per cent. of the seed planted failed to produce plants which reached the surface of the ground. Twenty-eight per cent. of those that reached the surface failed to develop normal tubers. Seventy per cent. of this seed produced plants which developed fair-sized tubers. These tubers were rough and more or less covered with both hyphae and sclerotia. Twenty per cent. of the plants showed traces of the fruiting stage. One hundred and fifteen pounds of seed produced 497 pounds of tubers. A return of 4 8-25 pounds for every pound of seed planted. The yield being nearly the same as that of the Check.

Results.—1. Diseased tubers are frequently prominent factors in producing crop failures.

2. The fruiting stage of this fungus apparently develops more freely on plants grown from tubers containing many sclerotia.

3. Carefully selecting seed free from sclerotia, but more or less covered with the hyphae of this fungus did not check its injuries to any marked extent, but the fruiting stage of the fungus developed less freely on the plants from the selected seed.

4. The standard corrosive sublimate treatment apparently checks the development of this disease when the treated seed is planted in new soil.

TABLE XI., SHOWING RESULTS OF EXPERIMENT NO. XI.

Plat Number	TREATMENT	Number Pounds of Seed Tubers Planted	Total Number Pounds of Tubers Harvested	Yield for Every Pound of Seed Planted	Gain	Yield in Sacks per Acre
I.	Check	325	1240	3.81		23
	Treated, Corrosive Sublimate 1 oz. to 8 gals. of water, 1½ hrs.	200	1080	5.40	41%	32
	Selected free from Sclerotia	115	497	4.32	13%	26

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Large Potato Vines and No Potatoes

...BY...

WENDELL PADDOCK

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*Large Potato Vines and No Potatoes

BY WENDELL PADDOCK.

This bulletin contains a condensed account of our work with potato diseases, the most of which has appeared in Bulletins 70 and 91 of this station, and its purpose is to supply information to the increasing number of correspondents who are becoming interested in potato growing. It is addressed primarily to those farmers who live outside of the successful potato-growing sections, but the best potato soils are by no means free from the troubles that are described below. By having a correct understanding of certain peculiar conditions of the potato plant, which have been ascribed to various causes, such as water, alkali, altitude, etc., it is possible that the most successful grower can modify his system of culture to advantage.

Most farmers who have tried to grow potatoes in this state and failed, or who have been only partially successful, will be familiar with the following conditions:

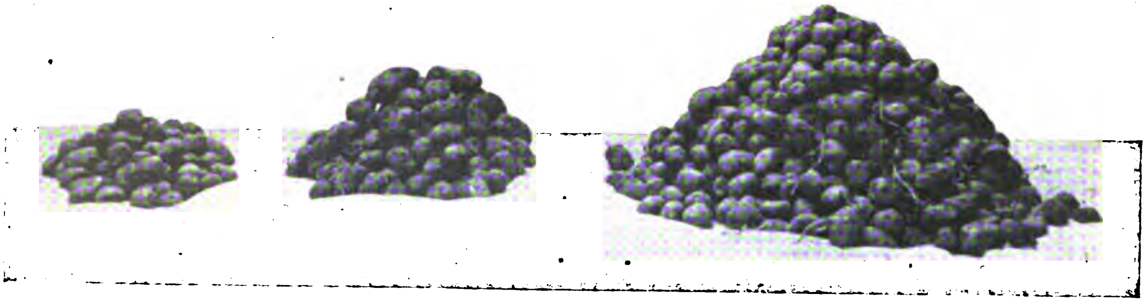
Good vines with no tubers or a cluster of small, worthless tubers; in many instances, even in the best potato soil, the plants fail to come up, or weak plants are produced, which die before the potatoes are mature, thus resulting in a poor stand; potato blight, or the dying of a portion or all of the vines; russeted and scabby potatoes; blight and scab also seen in the best potato districts; and finally, collar rot or black ring of the vine, at the surface of the ground.

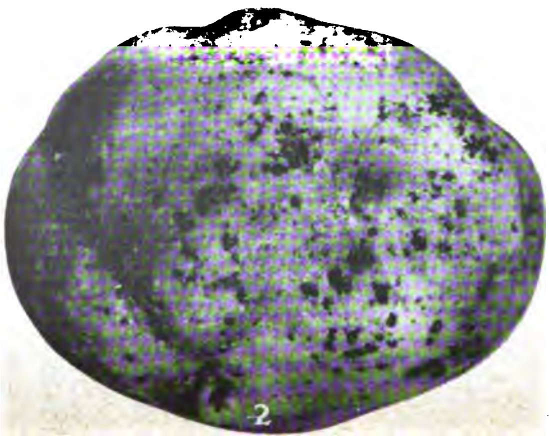
Experiments have proven that any and all of these conditions can be produced by the action of a certain plant disease, and observations in many parts of the state show that this fungus is abundant, and is undoubtedly responsible for most of the lack of success in potato growing.

Nature of the Disease. This fungus *(Corticium vagum* B. & C. var. *Solani,* Burt.) appears to grow naturally in this state, as it is found in the remote and newer parts, and it also attacks a number of plants other than the potato, both cultivated and wild. After the soil has become infected the fungus persists for a long time.

If the fungus is not already present, the soil will soon become infected after potatoes have been grown. This is true for the rea-

***Bulletins 70 and 91, by F. M. Rolfs, being technical in character, have not been sent to the general mailing list. Copies will, however, be sent on request.**





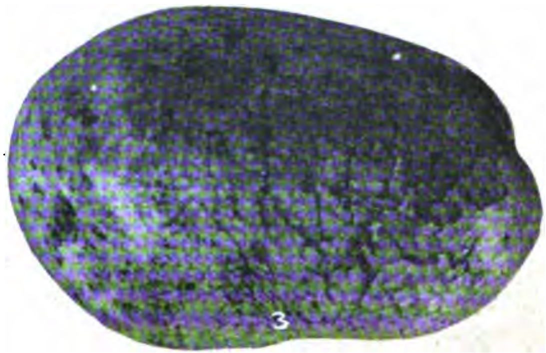


PLATE I.

son that it is difficult to find a sack of potatoes free from all traces of the disease. It lives over winter in the cracks of rough and russeted potatoes and in the ulcers of scab, and also in what appears to be patches of dirt which stick closely to the surface of the potato. By looking closely at these dirt-like appearing objects, which are well shown in Fig. 2, Plate I., it will be seen that they are not composed of ordinary soil. In fact, they are made up of the closely interwoven root-like organs of the fungus.

This tiny plant also produces an abundance of seed-like bodies or spores which help to spread it. They are borne only on green potato vines and just above the surface of the ground. Here a thin, delicate layer is formed that looks like a slight deposit of alkali, and the spores are borne on the tips of the threads of which it is composed.

A Poor Stand of Potatoes. When diseased potatoes are used for seed, or when clean potatoes are planted in infected soil, the fungus starts into growth with the young potato plant. The tender shoots are often attacked, with the result shown in Plate II. On the right are two shoots, which were rotted off by the fungus before they reached the surface of the ground. This illustrates how a poor stand of potatoes is often brought about. The other two were badly injured and might have become mature plants, but affected with the familiar collar rot or black ring.

Vines and no Tubers. The most damage is done, however, by cutting off the tuber stems, and this portion of the potato plant is especially liable to attack. These stems are often cut off as fast as they grow out, thus leaving no place on which tubers may form. But in some instances a cluster of small or "Little Potatoes" form around the main stem, seemingly the result of girdling by the fungus.

Potato Scab. The potato tubers are often made rough and scabby by the growth of the disease on their surfaces. (Plate I., Fig. 3.) All gradations of these injuries may be found, from a rough or russeted appearance to deep scabs or ulcers that greatly injure the appearance of the potato. Singularly enough, scab is more common in the best potato soil than it is in localities where the crop is precarious. Sandy or gravelly soils, when first brought under cultivation, often give a large per cent. of scabby potatoes, but after one or more crops of alfalfa have been plowed under, this tendency is partially corrected.

Potato Blight. Potato blight, or the dying of the leaves and vines before the crop is mature, is commonly thought to be entirely due to diseases which attack the top of the potato plant. We have not found it so in Colorado. Spraying experiments with Bordeaux

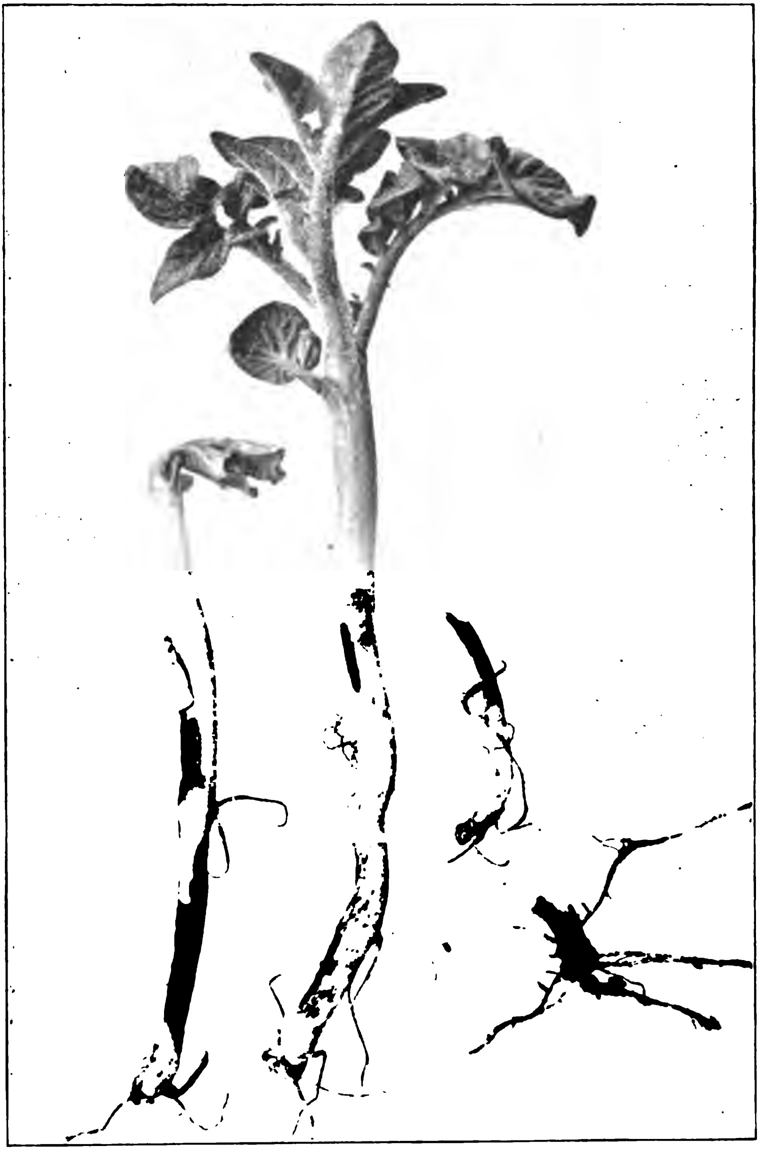


PLATE II.

mixture did not materially lessen the blight, and the microscopic plants which cause these leaf diseases are not commonly found associated with this trouble. We conclude, therefore, that the premature dying of the potato vines is usually an evidence that the underground parts have been severely injured by the fungus in question.

Running Out. The running out of potatoes, as it is called when the tubers become pointed or much elongated, appears also to be associated with the attacks of this fungus. But just what the relation is between the two has not yet been determined.

Treating the Seed. At first thought it would appear to be a simple matter to combat this disease by treating the seed with formalin or corrosive sublimate. In fact, some of our experiments with treated seed have shown decided gains, but others have given a loss. The results of this season are again negative, so it is doubtful if the seed treatment can be made to pay. This is true for the reason that most Colorado soils are thoroughly infected with the fungus and the treatment usually delays the sprouting of the seed and consequently injures the plant so that it does not yield as well as untreated seed.

Seed Selection. Better results have been secured by selecting smooth, round seed that was entirely free from disease. Such potatoes are not only free from disease, but the chances are that they were grown on vines that were not seriously affected by the fungus as run out potatoes usually occur on diseased vines. We would expect such seed to show a certain degree of resistance to the disease.

Disease-Resistant Varieties. The only prospect that we now have of ever overcoming this disease beyond what can be done by improved methods of culture, is to select seed from the healthiest plants that produce good shaped tubers, and thus gradually breed up a resistant strain. Last year over 80 varieties of potatoes were grown in the College garden in soil that was known to be badly diseased. Only 20 kinds out of this number were saved for further testing; the rest produced only a few small, misshapen tubers, and many of the vines bore none at all. This year the list has been still further cut down, though a few varieties yielded well. These were all dug by hand, and the hills that produced the best tubers have been saved for further testing. We hope in time to build up a strain of potatoes that will resist the attacks of this fungus by selecting from individual hills that are the least attacked by disease.

Not many potato growers can afford the time to follow up experiments of this kind, but a less rigid method of selection could be practiced by all. The following is quoted from Bulletin 91, of this Station:

"Another method which gives evidence of considerable practical value is to set aside each year five or ten acres of land for the growing of seed

potatoes. The soil of such tract ought to be fertile and free from the various diseases which attack the potato plant. The tubers used in planting the seed tract are carefully selected each year from the seed plat of the previous year. The surplus seed is used for planting the gneral crop, and in this way a stain of pedigree potatoes is gradually developed."

Culture. The best potato soil is a sandy or gravelly loam which contains an abundance of vegetable matter, and which is well underdrained. In the Greeley district the soil will average about four feet deep. Below this is an immense layer of gravel, which insures perfect drainage. Vegetable matter is secured by plowing under alfalfa sod. Alfalfa is grown two years, then turned under in the spring and planted to potatoes. Two crops of potatoes are grown in succession, then wheat is sown and the land again seeded to alfalfa, thus making a five-year rotation. The second crop of potatoes, however, is rarely as good as the first, probably because of the increase of the fungus in the soil, and in most localities but one crop of potatoes should enter into the rotation system.

A heavy alkaline soil, that has poor underdrainage, furnishes an ideal condition for the growth of this plant disease, and it is in such soils that potato failures are most frequent. But poor underdrainage in any soil is conducive to its growth. It will be seen, then, that cultivation and irrigation must be important factors in controlling the disease. Most people who attempt to grow potatoes make the mistake of using more water than is necessary for the best growth of the plants. The rows should be comparatively short, so that part of the ground will not need to be over-watered. The seed should be planted about four inches deep in rows 38 to 40 inches apart. The furrows should be about five inches deep for the first irrigation, and with subsequent irrigations they should be increased in depth. The idea is to make the furrows deep enough to supply sufficient moisture to the roots without saturating the upper portion of the ridge where the tubers form. Cultivation should follow as soon after as the ground is in condition to work. The condition of the soil and plants should always govern the amount and the frequency that water is applied.

After all has been done in the way of culture, seed selection and a long rotation of crops, the vines and weeds should be collected and burned each season after the potatoes have been dug. This will destroy a great deal of the fungus that would infect other fields, as the vines are scattered by various means.

Bulletin 93 **December, 1904**

The Agricultural Experiment Station

OF THE

Agricultural College of Colorado

Colorado Hays and Fodders.

ALFALFA—TIMOTHY—NATIVE HAY—CORN FODDER—SORGHUM—SALT BUSH.

DIGESTION EXPERIMENTS

— BY—

WILLIAM P. HEADDEN

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FORT COLLINS, COLORADO.

DIGESTION EXPERIMENTS WITH SOME COLORADO HAYS AND FODDERS.

BY WM. P. HEADDEN.

Some years ago, while making a study of the alfalfa plant and again on extending the work to a study of alfalfa and some other hays, I was surprised at the scarcity of data upon the digestibility of the various hays that I was endeavoring to study. The results of the experiments that I succeeded in finding were not only few in number but not concordant. Further, they were made with hays which could scarcely be compared with those that I was studying and under different conditions from those which obtain here.

It is accepted as a fact among us, whether justly so or not, that alfalfa or lucerne hay as grown and made in this state is scarcely excelled by any other hay for the purposes of milk-producing and fattening, for which it is used in large quantities. It is also probably true that the alfalfa grows as well under our conditions and makes as good a quality of hay as in any other locality in this country and perhaps in the world. It is for such reasons that it seemed to me desirable to make some experiments to determine anew the digestion coefficients of alfalfa hay produced here. It is true that these had been previously determined by my immediate predecessor, Dr. O'Brine, using steers to experiment with, but I wished to extend the experiments to include some other fodders. I deemed it desirable that still others should be added, because the accumulated data on this subject is neither extensive nor concordant. I therefore present the results of some experiments on the digestibility of some Colorado grown fodders, using sheep as our experimental animals.*

In Bulletin No. 39, I tried to set forth some of the differences between hays made from leguminous plants and the grasses. I have this problem in view in these experiments also, but rather incidentally, the principal purpose of this bulletin being to give the results of our attempts to determine the digestion coefficients

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* I wish to acknowledge the patient, faithful, cheerful, and interested service rendered by my assistants in the prosecution of this work. Some of my results being unusually low led to frequent repetitions as a matter of precaution. Some of the work too has been disagreeable, but my assistants have at all times done it willingly. It is with pleasure that I make this acknowledgment.

of some of our fodders, either because of their present importance or because of their possible interest to stockmen and feeders.

It may not be amiss to state some of the more salient differences between the leguminous hays and those made from grasses. The leguminous hays contain a larger portion soluble in water and alcohol by about 10 per cent than the native hay, the amount of hemicellulose, cellulose like constituents reacting with phloroglucin, is much larger in the leguminous hays than in the native hays. These two facts may account for the greater sensitiveness that the leguminous hays show to the effects of moisture. I have seen alfalfa badly discolored by a heavy dew. These facts, too, may indicate even greater differences than we at present realize. The extractive as well as the nitrogenous substance are probably quite different, which is also certainly true among the grasses as well.

The leguminous hays are as a class sensitive to the action of water and inclined to heat readily. Under our Colorado conditions the action of water is often wholly avoided and the hay has a bright green color and a marked pleasant odor. One would expect such hay to be more uniform in quality and superior to that made in states where it is difficult to cut and cure the hay without its being more or less damaged by rains or heavy dews.

I do not know to what extent the quality of the hay affects its digestion coefficients, but alfalfa hay is certainly sensitive to the action of even a slight amount of moisture in the form of rain or dew. I have but little data conveying any idea of how sensitive it is or of the character of the changes produced in it. I have had opportunity to study but one sample in any detail; in this case I do not know what percentage of the original hay was washed out, the hay did not heat; it was simply cut at one of those inopportune periods when it rains every few hours even in Colorado. The total rainfall during this wet period was 1.76 inches. The hay which escaped the rain contained 26.46 per cent crude fibre; that which was exposed to it contained 38.83 per cent, the former contained 18.71 per cent protein the latter 11.01. The nitrogen free extract, which includes the hemicelluloses was reduced about five per cent. These statements and figures may serve both to justify and explain my statement that legume hay, especially alfalfa, is very sensitive to the action of moisture and fermentation. In the case of brennheu, the fermentation seems to make it more palatable to cattle. I have never heard of this effect having been produced in the case of hays made from grasses, this, however, may be the case, but I have not met with any statement to this effect. The large portion of the legume hays soluble in water and easily fermentable accounts for their rapid deterioration when exposed to excessive moisture and heat. The amount

dissolved by alcohol and cold water from alfalfa hay is about 36 per cent, while the same menstruua dissolve only 27 per cent from native hay and 28 from timothy.

In the case of native hay, the results will doubtlessly vary with the different amounts of the various grasses which make up the hay. A hay consisting of blue stem principally will differ from one made up of a mixture of grasses, and probably still more from one consisting largely of sedges. This consideration should not be lost sight of when any statement concerning a native hay is made, for the statement may be based upon results obtained in experiments with a hay very different from the one the reader may have in mind. The mixture of grasses represented by the term native hay, is indicated by the sample used in Bulletin 39, in which we find the following: *Andropogon scoparius*, *Carex marcida*, *Elymus canadensis*, *Panicum virgatum*, *Sporobolus asperifolius*, *Sporobolus cryptandrus*, *Poa tennuifolio*, *Andropogon furcatus*, *Chrysopogen avenacrus*, *Calamovilja longifolio*, *Agropyron tenerum*, and *Bouteloua oligostachya*. This mixture represented an excellent sample of this class of hay, but results obtained with it can only in a measure be applied to another hay representing a different mixture of grasses, i. e., to one consisting almost wholly of blue stem, *Agropyron tenerum*, or rushes and sedges.

I recognize the necessity of having a representative sample of hay, even when the hay is composed exclusively of one plant, which is the case in the alfalfa hay, and for this reason alone I make the following statements:

The sample of alfalfa hay used was furnished by the Farm Department. The practice is, when possible, to cut the alfalfa before it is more than in half bloom, and this hay was probably cut when the alfalfa was in this condition, but the analysis agrees better with the composition of a hay cut at a later period, i. e., when in full bloom or even past this stage. The hay was not first class hay.

The results obtained with this sample were so exceptional, especially in regard to the ether extract or fat, that the analytical work was repeated in the case of the hay and the feces of sheep No. 3. The principal weakness in my data lies in the sample of hay itself, which is quite normal in its composition except in regard to the amount of ether extract or so called fat that it contains, of which there is even a little less than I have heretofore found in the stems or in hay made from plants in full seed. The protein, 13.12 per cent, is a shade low, and the crude fibre 41.05 per cent, a trifle high for really good alfalfa hay, but they are not abnormal enough to justify their rejection. The ether extract, however, being less than one half the amount usually found in

average samples of alfalfa hay is open to serious doubt. The feces voided by sheep feeding on this hay are, on the other hand quite as rich in ether extract as those of sheep which had been feeding on much better hay.

The case presents itself to me in the following light, as it will probably present itself to others, i. e., if the feces of two sets of sheep feeding on the same kind of hay show practically the same amount of the ether extract, we ought to find a corresponding agreement in the amount of ether extract in the respective hays, provided the digestive processes have acted upon them in the same manner and degree. But we do not find this to be the case, and I view the discrepancy as of such importance that I consider it my duty to reject this series of experiments with alfalfa hay or to give the results obtained and a fuller account of the study made in our endeavor to find the error, or some explanation for the results obtained. I shall give the series with all results as found and then an account of the work done.

The digestion coefficient for the ether extract seems to be the only one concerning which any serious question can be raised. The coefficient obtained being negative cannot be used, but it seems to me that there must be some facts indicated by this result, for, though the agreement of the coefficients found is very poor, they agree in their general purport, i. e., they are all three negative. The hay seems to have undergone some change which lessened the amount of ether extract in the hay, but in passing through the digestive processes it appears to have been rendered soluble again. This can scarcely be the case. The excess is more likely due to ether soluble substances in the feces which are not furnished by the undigested portions of the hay.

The sheep used in the first four series of experiments were wethers between three and four years old.

The fodders used were corn fodder, native hay, timothy hay and alfalfa hay.

The animals were fed for a period of twelve days and the feces collected during the last five days.

CORN FODDER.

Fodder Fed.—Sheep No. 3.

Weight of fodder received in five days, 5395.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.*	Extract.
7.02	11.11	1.36	8.66	32.37	39.48

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5016.27	599.38	73.37	467.20	1746.36	2129.95

**Orts, air dried, weighed 606.0 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.71	24.18	1.28	8.36	31.25	28.28

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
565.34	146.53	7.76	50.66	189.37	171.38

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5016.27	599.38	73.37	467.20	1746.36	2129.95
Less orts	565.34	146.53	7.76	50.66	189.37	171.38
Consumed	4450.93	442.85	65.61	416.54	1556.99	1958.57

Feces.

Air dried feces weighed 1965.5 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.11	13.73	1.86	10.89	24.22	42.20

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1825.75	269.86	36.56	214.04	478.04	829.34

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4450.93	442.85	65.61	416.55	1556.99	1958.57
Voided	1825.75	269.86	36.56	214.04	478.04	829.34
Digested	2625.18	172.99	29.05	202.51	1078.95	1129.23
Co-efficients or percentages digested	**58.98**	**39.06**	**44.28**	**48.62**	**69.30**	**57.66**

*Fibre is used throughout these tables for crude fibre, and extract for nitrogen free extract.

**Orts is the portion left by the animal.

CORN FODDER.

Fodder Fed—Sheep No. 5.

Weight of fodder received in five days, 5395.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.02	11.11	1.36	8.66	32.37	39.48

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5016.27	599.38	73.37	467.20	1746.36	2129.95

Orts, air dried, weighed 453.5 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.02	23.07	1.56	8.70	30.47	29.18

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
421.65	104.62	7.07	39.45	138.18	132.33

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5016.27	599.38	73.37	467.20	1746.36	2129.95
Less orts	421.65	104.62	7.07	39.45	138.18	132.33
Consumed	4594.62	494.76	66.30	427.75	1608.18	1997.62

Feces.

Air dried feces weighed 1978.5 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.76	14.43	1.83	11.66	24.19	40.13

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1825.00	285.50	36.20	230.69	478.59	793.97

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4594.62	494.76	66.30	427.75	1608.18	1997.62
Voided	1825.00	285.50	36.20	230.69	478.59	793.97
Digested	2769.62	209.26	30.10	197.07	1129.59	1203.65
Co-efficients or percentages digested	**60.28**	**42.29**	**45.40**	**46.07**	**70.24**	**60.25**

CORN FODDER.

Fodder Fed.—Sheep No. 10.

Weight of fodder received in five days, 5395.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.02	11.11	1.36	8.66	32.37	39.48

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5016.27	599.38	73.37	467.20	1746.36	2129.95

Orts, air dried, weighed 500.50 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.33	18.89	1.40	10.03	30.00	34.35

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
473.82	94.55	7.01	50.21	150.12	167.96

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5016.27	599.38	73.37	467.20	1746.36	2129.95
Less orts	473.82	94.55	7.01	50.21	150.12	167.96
Consumed	4542.45	504.83	66.36	416.99	1596.24	1961.99

Feces.

Air dried feces weighed 2115.50 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.43	12.63	1.63	10.36	27.11	41.82

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1979.36	267.19	34.48	219.11	573.57	884.85

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4542.45	504.83	66.36	416.99	1596.24	1961.99
Voided	1979.36	267.19	34.48	219.11	573.57	884.85
Digested	2563.09	237.64	31.88	197.88	1022.67	1077.14
Co-efficients or percentages digested	**56.43**	**47.08**	**48.04**	**47.46**	**64.07**	**54.90**

Average Coefficients, as Given by the Three Sheep.

	Dry Matter.	Ash.	Fat.	Protein.	Crude Fibre.	N. Free Extract.
Sheep No. 1	**56.43**	**47.08**	**48.04**	**47.46**	**64.07**	**54.90**
Sheep No. 2	**60.28**	**42.29**	**45.40**	**46.07**	**70.24**	**60.25**
Sheep No. 3	**58.98**	**39.06**	**44.28**	**48.62**	**69.30**	**57.66**
Average	**58.56**	**42.84**	**45.91**	**47.38**	**67.87**	**57.60**

The corn fodder used was a dent corn, sown broadcast and cut quite immature; some of the plants were in silk, but no corn was formed on the ears. The fodder was about eight months old when fed.

NATIVE HAY.

Fodder Fed.—Sheep No. 2.

Weight of fodder received in five days, 5380.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.23	7.33	2.05	7.36	35.78	41.70

Fodder Constituents Fed, In Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5044.88	394.35	110.29	394.32	1924.10	2243.22

Orts, air dried, weighed 429.0 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.85	8.77	1.70	7.21	38.17	38.29

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
403.91	37.62	7.29	30.93	163.72	164.21

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5044.88	394.35	110.29	394.32	1924.10	2243.22
Less orts	403.91	37.62	7.29	30.93	163.72	164.21
Consumed	4640.97	356.73	103.00	363.39	1760.38	2079.01

Feces.

Air dried feces weighed 1832.5 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.06	10.16	2.68	7.11	35.93	39.06

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1721.50	186.12	49.11	130.21	658.47	715.71

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4640.97	356.73	103.00	363.39	1760.38	2079.01
Voided	1721.50	186.12	49.11	130.21	658.47	715.71
Digested	2919.47	170.61	53.89	233.18	1101.91	1363.30
Co-efficients or percentages digested	**62.91**	**47.82**	**52.32**	**67.47**	**62.59**	**65.57**

NATIVE HAY.

Fodder Fed.—Sheep No. 5.

Weight of fodder received in five days, 5380.0 grains.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.23	7.33	2.05	7.36	35.78	41.70

Fodder Constituents Fed, In Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5044.88	394.35	110.29	394.32	1924.10	2243.22

Orts, air dried, weighed 553.5 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.30	8.34	1.53	6.98	38.31	38.54

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
518.63	46.16	8.47	38.63	212.02	213.35

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5044.88	394.35	110.29	394.32	1924.10	2243.22
Less orts	518.63	46.16	8.47	38.63	212.02	213.35
Consumed	4526.25	348.19	101.82	355.69	1702.08	2029.87

Feces.

Air dried feces weighed 1968.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.58	10.46	2.74	7.68	32.43	40.14

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1838.59	205.82	53.92	151.12	638.23	789.91

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4526.25	348.19	101.82	355.69	1702.08	2029.87
Voided	1838.59	205.82	53.92	151.12	638.23	789.91
Digested	2687.66	142.37	47.90	204.57	1063.85	1239.96
Co-efficients or percentages digested	**59.38**	**40.89**	**47.14**	**57.51**	**62.50**	**61.08**

NATIVE HAY.

Fodder Fed.—Sheep No. 10.

Weight of fodder received in five days, 5380.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.23	7.33	2.05	7.36	35.78	41.70

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5044.88	394.35	110.29	394.32	1924.10	2243.22

Orts, air dried, weighed 433.5 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.09	6.44	0.96	5.37	36.98	44.16

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
407.10	27.91	4.16	23.27	160.31	191.43

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5044.88	394.35	110.29	394.32	1924.10	2243.22
Less orts	407.10	27.91	4.16	23.27	160.31	191.43
Consumed	4637.78	366.44	106.13	371.05	1763.79	2051.79

Feces.

Air dried feces weighed 2130.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.48	10.14	2.90	7.37	33.97	39.14

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1991.96	215.91	61.77	156.91	723.52	833.61

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4637.78	366.44	106.13	371.05	1763.79	2051.79
Voided	1991.96	215.91	61.77	156.91	723.52	833.61
Digested	2645.82	150.53	44.36	214.14	1040.27	1218.18
Co-efficients or percentages digested	**57.05**	**41.24**	**41.80**	**57.71**	**58.98**	**59.37**

The Average Coefficients found for Native Hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 2	**62.91**	**47.82**	**52.53**	**67.47**	**62.59**	**65.57**
Sheep No. 5	**59.38**	**40.89**	**47.14**	**57.51**	**62.50**	**61.08**
Sheep No. 10	**57.05**	**41.24**	**41.80**	**57.71**	**58.98**	**59.37**
Average	**59.78**	**43.32**	**47.09**	**60.90**	**61.36**	**62.01**

Jordan and Hall give a blue joint under meadow grasses. I do not know whether this is our blue joint or not, but for this they give the following coefficients:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Maximum	68.6	48.7	52.3	70.2	72.4	68.6
Minimum	39.9	10.0	37.0	56.5	36.5	43.2
Average	54.3	29.4	44.7	63.4	54.5	55.9

This blue joint is probably *Calamagrostis canadensis*, while our blue stem is *Agropyron tenerum*. I know of no data on this subject applicable to our native hay, unless the comparison be made under the very broad head of meadow hay, which is, perhaps, a little too broad.

The native hay used in this experiment was purchased in the market as "upland hay." It was said to have been cut on the farm of Mr. Gilkison and was composed largely of blue joint *Agropyrum tenerum*.

I do not think that the coefficients of digestion of this class of hay have been determined, at least I can find none.

Such hay is cut from the bottom lands along the water courses, or where water courses have been and the supply of moisture is both greater and more constant than in the higher ground. It can scarcely be compared with Eastern meadow hay, though such a comparison would, in a measure, be justified.

TIMOTHY HAY.

Fodder Fed.—Sheep No. 3.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.58	7.21	1.43	7.45	40.71	36.52

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5166.19	398.77	79.08	411.91	2251.31	2019.18

Orts, air dried, weighed 000 grams.

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5166.19	398.77	79.08	411.91	2251.38	2019.18

Feces.

Air dried feces weighed 2349.50 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.07	11.10	2.49	7.45	41.85	32.04

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2230.35	260.71	58.51	175.03	983.22	752.71

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5166.19	398.77	79.08	411.91	2251.38	2019.18
Voided	2230.35	260.71	58.51	175.03	983.22	752.71
Digested	2935.84	138.06	20.57	236.88	1268.16	1266.47
Co-efficients or percentages digested	**56.83**	**34.62**	**26.01**	**57.51**	**56.33**	**62.72**

TIMOTHY HAY.

Fodder Fed.—Sheep No. 4.

Weight of fodder received in five days, 5530.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.58	7.21	1.43	7.45	40.71	36.52

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5166.19	398.77	79.08	411.91	2251.31	2019.18

Orts, air dried, weighed 000 grams.

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5166.19	398.77	79.08	411.91	2251.31	2019.18

Feces.

Air dried feces weighed 2275.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.46	10.31	2.23	7.48	42.00	31.48

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2091.19	235.42	50.73	170.11	955.41	716.11

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5166.19	398.77	79.08	411.91	2251.31	2019.18
Voided	2091.19	235.42	50.73	170.11	955.41	716.11
Digested	3075.00	161.35	28.35	241.80	1295.97	1303.07
Co-efficients or percentages digested	**59.52**	**32.94**	**35.85**	**58.70**	**57.56**	**64.53**

TIMOTHY HAY.

Fodder Fed.—Sheep No. 8.

Weight of fodder received in five days, 5530.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.58	7.21	1.43	7.45	40.71	36.52

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5166.19	398.77	79.08	411.91	2251.38	2019.18

Orts, air dried, weighed 65.0 grams.*

Analysis of Orts.

Analysis incomplete.

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
	13.91	1.30	8.82		

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5166.19	398.77	79.08	411.91	2257.38	2019.18
Less orts		13.91	1.30	8.82		
Consumed	5166.19	384.86	77.78	403.09	2251.38	2019.18

Feces.

Air dried feces weighed 2567.5 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.98	9.77	2.06	6.45	43.93	30.80

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2388.21	250.71	51.50	165.62	1127.11	790.71

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5166.19	384.86	77.78	403.09	2251.38	2019.18
Voided	2388.21	250.71	51.50	165.62	1127.11	790.71
Digested	2777.98	134.15	26.28	237.47	1124.27	1228.47
Co-efficients or percentages digested	**53.77**	**34.86**	**33.79**	**58.91**	**49.94**	**60.79**

*The moisture and crude fibre determinations in this sample of orts were omitted, which introduces a slight error into the co-efficients obtained.

Average Digestion Coefficients for Timothy Hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 3	56.83	34.62	26.01	57.51	56.33	62.72
Sheep No. 4	59.52	32.94	35.85	58.70	57.56	64.53
Sheep No. 8	53.77	34.86	33.79	58.91	49.94	60.79
Average	56.71	34.14	31.88	58.37	54.61	62.80

The average coefficients obtained are well within the range found by other experimenters, with the exception of the coefficient of digestion for the fat or ether extract, which is far below the coefficient given for fat in timothy hay cut before or in bloom, and even lower than the minimum given for fat, 34.6, in timothy hay cut past bloom. The digestion coefficient of crude fibre is lower than the minimum given for timothy hay cut before or in bloom, but above the maximum for timothy cut after bloom. The digestion coefficient for the fat is markedly low. The same fact is observable in the results obtained for the digestion coefficient of fat in corn fodder. The native hay gives us a higher coefficient for the digestibility of the fat or ether extract than is given for blue joint, a meadow grass common in the East; but as already noted, the Eastern blue joint and the Western blue stem are different grasses, and their digestion coefficients may not be the same, in fact, are probably not the same, and my only justification in comparing them is the very general one that they each constitute a meadow hay.

We will have to take up the question of the digestion coefficient of fat in a subsequent paragraph, after we have set forth the results obtained with alfalfa hay.

The timothy hay used was purchased in the Denver market, it had been grown in the mountains, had been cut in early bloom and well cured. It was as good a sample as we could hope to procure either in the market or by growing it o n the Station arm.

ALFALFA HAY.

Fodder Fed.—Sheep No. 4.

Weight of fodder received in five days, 5470.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.23	9.63	0.80	13.12	41.05	30.17

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5183.88	526.72	43.76	717.63	2245.23	1650.34

Orts, air dried, weighed 000 grams.

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5183.88	526.72	43.76	717.63	2245.23	1650.34

Feces.

Air dried feces weighed 2340.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.21	10.30	3.06	9.44	44.23	26.76

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2194.63	241.07	71.60	220.80	1034.10	626.11

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5183.88	526.72	43.76	717.63	2245.23	1650.34
Voided	2199.63	241.07	71.60	220.81	1034.10	626.11
Digested	2989.25	285.65	—27.84	496.82	1211.13	1024.23
Co-efficients or percentages digested	**57.66**	**54.23**	**—63.61**	**69.06**	**54.43**	**62.06**

ALFALFA HAY.

Fodder Fed.—Sheep No. 3.

Weight of fodder received in five days, 5470.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.23	9.63	0.80	13.12	41.05	30.17

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5183.88	526.72	43.76	717.63	2245.23	1650.34

Orts, air dried, weighed 000 grams.

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5183.88	526.72	43.76	717.63	2245.23	1650.34

Feces.

Air dried feces weighed 2832.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.26	11.12	3.27	9.27	44.00	26.08

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2654.68	315.03	92.63	262.65	1246.19	738.82

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5183.88	526.72	43.76	717.63	2245.23	1650.30
Voided	2654.68	315.03	92.63	262.65	1246.19	738.82
Digested	2529.20	211.69	—48.87	454.98	999.04	911.52
Co-efficients or percentages digested	**49.56**	**40.19**	**—111.67**	**63.40**	**44.49**	**55.23**

ALFALFA HAY.

Fodder Fed.—Sheep No. 8.

Weight of fodder received in five days, 5470.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.23	9.63	0.80	13.12	41.05	30.17

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
5183.88	526.72	43.76	717.63	2245.23	1650.30

Orts, air dried, weighed 1522.0 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.44	11.12	0.84	12.44	36.48	32.68

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1423.98	169.24	12.78	189.34	555.23	497.33

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	5183.88	526.72	43.76	717.63	2245.23	1650.34
Less orts	1423.98	169.24	12.78	189.34	555.23	497.39
Consumed	3759.90	357.48	30.98	528.29	1690.00	1152.95

Feces.

Air dried feces weighed 2044.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.99	10.00	2.99	8.38	46.00	26.64

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1921.57	205.40	61.11	171.22	940.22	544.55

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3759.90	357.48	30.98	528.29	1690.00	1152.95
Voided	1921.57	205.40	61.11	171.22	940.22	544.55
Digested	1838.33	152.08	—30.13	357.07	749.78	608.40
Co-efficients or percentages digested	**48.89**	**42.57**	**—97.26**	**67.59**	**44.36**	**52.77**

Average Digestion Coefficients for Alfalfa Hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 3	**49.56**	**40.19**	Negative **111.67**	**63.40**	**44.49**	**55.23**
Sheep No. 4	**57.66**	**54.23**	Negative **63.61**	**69.08**	**54.43**	**62.06**
Sheep No. 8	**48.89**	**42.54**	Negative **97.26**	**67.59**	**44.36**	**52.77**
Averages	**52.04**	**45.65**	Negative **90.85**	**66.69**	**47.76**	**56.69**

The maximum, minimum and average coefficients of digesgestion as given by Jordan and Hall are as follows:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Maximum	60.2	40.9	54.0	77.0	49.0	71.8
Minimum	57.0	38.0	48.4	68.8	43.3	64.0
Average	58.9	39.5	51.0	72.0	46.0	69.2

The experiments on which the quoted data were based were made, one by Utah Experiment Station, using two steers; one by the New York Experiment Station, using a cow; one by the Colorado Station, using two steers. Additional experiments which have appeared since the compilation of Jordan and Hall was made are, so far as I have been able to find, the following:

Kansas Station, Bulletin 103.—Steers.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
First cutting, plants in bloom	59.40	63.49	60.00	78.52	46.10	75.31
Second cutting, 50 per cent. of plants in bloom	58.29	56.41	30.39	75.14	50.44	71.99
Third cutting, plants in full bloom	60.03	60.90	51.65	76.70	50.63	75.24

Minnesota Station, Bulletin 80.—Steers.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Alfalfa hay	65.84	51.40	55.88	75.38	57.57	71.86

Ontario Agricultural College and Experimental Farm Report, 1898.—Sheep.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
First cutting	58.6	——	48.8	73.4	39.1	71.8
Second cutting	56.2	——	50.4	72.8	37.7	70.1
Third cutting	51.3	——	44.1	64.4	37.1	64.0

Utah Station.—Bul. 54.—Steers.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
60.16	40.85	50.57	70.30	45.67	71.80

These give for alfalfa hay, first cutting, taking the Minnesota and Utah samples as such, the following:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Average alfalfa hay	61.00	51.58	53.81	74.40	47.11	72.49
Average all cuttings	58.73	56.61	48.97	73.33	45.54	71.41

My average results are lower than the averages of other experimenters, but are within the bounds of probability, with the exception of the fat or ether extract, which in my series is negative, and we assume, tentatively only, that the results are erro-

neous, even though the three sheep give the same result, i. e., a negative one. The natural explanation would be to attribute it to some error, and as the result is common to the three sheep, the error, if any has been made, must be a fundamental one, and would seem to lie in the determination of the fat or ether extract in the hay itself. The hay used was first cutting hay, furnished by the Farm Department, probably cut when the plants were in early to half bloom, as it is our custom to cut the alfalfa when in this condition, though the analysis corresponds to much later cut hay.

The results in the case of the ether extract being so remarkable, the analytical work, though already done in duplicate, was repeated in the case of the hay and the feces of sheep No. 3. The principal weakness in my data lies in the sample of hay, the composition of which shows nothing unusual except a very small amount of fat, ether extract, which is even less than I have heretofore found in the stems alone or in hay made from plants that were in full seed.

This extremely low percentage of fat almost forbids the use of the coefficient obtained for it in this series of experiments.

The crude protein, 13.12 per cent, is a shade low, and the crude fibre, 41.05 per cent, a little too high for prime, first cutting alfalfa hay. But they are so well within the range found for these constituents in alfalfa hay that they cannot justly be made the subject of adverse comment. The fat, however, being less than one-half the amount usually found in good alfalfa hay, is open to the gravest doubts. The feces of the sheep fed on this hay are, on the other hand, quite as rich in ether extract as the feces of other sheep fed with a much better alfalfa hay. The average ether extract found in the feces of this series of experiments, and being the average of fifteen determinations, is 3.10 per cent, while the average percentage of ether extract found in the feces of three other sheep, likewise based upon fifteen determinations, is 3.09 per cent.

It would seem that if the feces of two sets of sheep, to which the same kind of hay had been fed, contained the same amount of ether extract (fat), we ought to find a corresponding agreement in the amounts contained in the hay feed, provided that the digestion processes had acted upon them in the same manner and degree ; but we do not find this to be the case, as will appear more fully in the statement of a subsequent series of experiments. I therefore feel it to be incumbent upon me either to reject this series or to make a somewhat full record of the study made, which I shall do as briefly as possible. It would be easier to do the former and to use only such results as are in harmony with other experiments which are considered as altogether reliable, and the number of which add materially to their conclusiveness.

The hay was passed through a cutter and the sample taken by Professor W. W. Cooke, who was at the time Professor of Agriculture at this institution, and by him delivered to me. The hay was discolored to a degree which might be produced by its being exposed to a heavy dew or a light rain. An analysis of it indicated it to be at least a fair quality of hay, the only thing attracting attention being the very unusually low percentage of ether extract or fat.

Two things were possible in our results: We might have obtained too low results in our analysis of the hay, or those obtained for the fat in the feces might have been too high, and it is conceivable that both determinations might have been wrong, even though the former was made in duplicate and the latter was the average of five closely agreeing determinations. The analysis of both the hay and the feces were repeated without changing the results. It was then thought the alfalfa being very rich in chlorophyll, the coloring matters might have accumulated in the feces and possibly, having been rendered more readily soluble in ether, might account for a part of the discrepency between our results and those of others. The hay and feces of sheep Nos. 3, 4 and 8 were resampled, the samples carefully dried in hydrogen and extracted with petroleum ether, boiling from 35 deg. to 50 deg. Petroleum ether of this boiling point dissolved about 50 per cent as much out of both hay and feces as the anhydrous ether. The petroleum ether Bp. 35 deg.–50 deg., dissolved 1.78, 1.97 and 1.78 per cent from the feces, whereas the anhydrous ether dissolved 3.64, 3.62 and 3.62 per cent. The petroleum extract had a yellowish green color and it was evident that there was some coloring matter present which was freely soluble in this menstruum.

An attempt to separate the fatty acids and in this manner to eliminate the question of coloring matters and bile products, gave unsatisfactory results.

We next tried a higher boiling petroleum, 50 deg.–60 deg. We found this much more difficult to work with than the lower boiling petroleum, and further, that it yielded a much higher percentage of extract, in one instance falling only 0.10 per cent below the ether and in no instance more than 1 per cent less than the ether. After extracting five samples with petroleum Bp. 50 deg.–60 deg., we abandoned it and had recourse to alternate extraction with petroleum Bp. 35 deg.–50 deg. and anhydrous ether, also treating same samples in reverse order. As a result of this treatment we found that samples treated with ether yield but little, 0.07 per cent average of three trials, to petroleum Bp. 35 deg.–50 deg., while those treated with petroleum Bp. 35 deg.–50 deg. yield 0.90 per cent to the ether. At first I supposed that this difference was due to chlorophyll soluble in ether, but insol-

uble in the petroleum; subsequent attempts to separate the coloring matters from these extracts, though very unsatisfactory in themselves, indicate that this assumption was not wholly justified. The coefficient of digestion for the fat, petroleum extract, was negative, as in the case of the ether extract—showing over twice as much fat in the feces as was ingested with the hay; the negative coefficient for the ether extract being 111.67 and for the petroleum 110.8.

The next thing suggesting itself was that the excess of substances extracted from the feces by the ether might be due to biliary products, and we sought for cholesterine and bile pigments. We did not obtain satisfactory crystallizations of cholesterine, but we did obtain a good Petenkofer reaction. This is hardly to be wondered at, as this substance occurs so generally distributed within the body. We obtained fairly good reactions for bile pigments, and were it not for the presence of other substances which might have produced the reactions observed, one would be justified in asserting that they were present. As the matter stands, however, I am very doubtful about the actual presence of bile pigments, and I am very fully convinced that this class of products do not furnish the explanation for the excessive amount of extract in the feces. By excessive is here meant relative to the amount in the hay feed.

We attempted to determine the chlorophyll in these extracts; the results were, as was to be foreseen, unsatisfactory, but indicated that from 30 to 35 per cent of the extract consists of chlorophyll and related substances. The petroleum extract was not colorless, but contained a considerable quantity of coloring matter. This coloring matter was also soluble in ether, for when the sample was first extracted with ether, and then with petroleum, the latter remained colorless. The large amount of coloring matter in alfalfa gave us trouble in other operations; for instance, we found it necessary to use lead and copper salts jointly in obtaining a colorless solution from an alcoholic extract of alfalfa hay.

The question of the coloring matters was not prosecuted further and was considered to this extent only because of their direct disturbing influence upon our fat determinations and indirectly upon some of our work due to the color imparted to the solutions, making it difficult to observe the reactions or to determine when the end had been reached.

In all of this we have been unable to find any explanation of the fact that this series of experiments gives us no digestion coefficient for the ether extract in alfalfa hay. I have canvassed all of the analytical difficulties which have occurred to me as possibly being capable of furnishing even a suggestion of an explanation, the analysis of the hay and also those of the feces have been repeated several times by different operators and with great

care. The results are so constant that they preclude any mistake in the analytical work. To convey an idea of the care with which my assistants worked and the concordant results obtained, I may be permitted to give some of them: Ether extract in alfalfa hay, 0.783, 0.835, 0.785, 0.812 and 0.750, after resampling and prolonged drying in hydrogen. Ether extract in the only sample of orts left by the sheep was 0.827, 0.850. The results obtained in the analysis of the feces were equally satisfactory.

The only suggestion remaining is that the hay used in this experiment had suffered some change which affect the solubility of the "ether extract" in this remarkable manner, i. e., reducing it to about one-half the amount to be expected in good alfalfa hay, this hay showing 0.80 per cent, while the next sample experimented with contained 1.62 per cent and was likewise first cutting but in much better condition. The orts show the same relation; the orts in this series show an average of 0.83 per cent ether extract, in the next one to be given 1.22 per cent. Of the three sheep used only one left any portion of its fodder, and I am inclined to consider it an accident that the fat in the hay and orts in this one sample are so nearly the same. The feces, on the other hand, do not show this difference, but are very similar in the percentage of ether extract yielded.

As already stated, the feces from this hay containing only 0.80 per cent ether extract yielded as the average of fifteen determinations made on the feces of three sheep 3.10 per cent, while the feces from another alfalfa hay yielded as the average of the same number of determinations made on the feces of three other sheep 3.09 per cent. One thing is evident, i. e., that however changed the hay may have been, this change did not affect the amount of ether extract appearing in the feces.

There are no facts that I know of to justify us in assuming that oxidation would diminish the solubility of the fats in alfalfa hay, even if slightly damaged by rain or dew, as this may have been. Beyond this I cannot conceive by what cause the fat in this hay could have been so reduced, and I am still less able to apprehend what changes could have taken place within the animal to restore an apparently *normal* amount of ether extract to the feces.

It is almost certain that the ether extract consists of soluble fecal matter, the amount of which is not dependent upon the amount of ether extract in the hay, and the coefficient obtained is of but little value.

It is generally accepted as a fact that the determination of the coefficient of digestion of fat, especially when only small amounts are fed, is at best unsatisfactory. This is applicable in the case of hays and fodders in which the amount of fat or ether

extract is small. In the case here presented the largest amount of ether extract consumed in the five days during which the feces were collected was 43.76 grams, a little less than an ounce and a half. This is a small quantity, but concerning the result there is no room for questions, it is not doubtful, for we find in the feces 92.63 grams of fat or ether extract—more than twice the amount consumed, and we find almost exactly the same ratio if we take the petroleum extract, i. e., 23.52 grams consumed and 48.99 grams voided in the feces. All uncertainty in regard to the coefficient disappears in this markedly negative result. While I am unable to give any explanation, satisfactory or otherwise, for this anomalous result, except as already suggested, I cannot, in fairness, do otherwise than publish the results obtained.

I see but one question which can still be raised, i. e., the character of the sample itself. The experience of Professor Cooke as a chemist and his own interest in the experiment ought to be a sufficient guaranty of its fairness. The fact that the one sample of orts obtained in the experiment gives the same amount of ether extract that the sample of hay gave is remarkable, for sheep, when they have the opportunity, eat the leaves of alfalfa in preference to the stems, and the fact that this hay had been chopped would in no way preclude the animals leaving the stems in preference to a mixture of leaves and stems. The analysis, as already intimated, suggests a sample of hay which had been cut when passed full bloom, but by what process the ether extract in the feces has been rendered so large is not apparent.

SECOND SERIES.

It was my intention to extend the work with the preceding hays and fodders to include a study of the alcoholic and aqueous extracts together with several other points which appear to me interesting and possibly of considerable value. The doubts which gathered about the alfalfa hay and the anamalous results obtained decided me to take up another series of experiments. I accordingly obtained other sheep and repeated the work *de novo*. I was the more willing to do this, as it would increase the number of experiments made and the number of animals experimented with, both of which are desirable factors in this kind of work, besides there is a scarcity of experiments to determine the coefficients of some of the fodders with which I wished to experiment. Some of the conditions, too, under which the experiments were conducted were made more favorable. The comfort of the animal was better provided for and the spring season was chosen instead of the summer.

It further seemed advisable to extend the experiments to include sorghum fodder raised without irrigation and one of our na-

tive salt bushes, *Atriplex argentea*, because they are of importance to the eastern section of the state, which is largely devoted to grazing. The cattlemen find it desirable to have some fodder to feed during severe storms, as by doing so they avoid during the late winter and spring the loss of cattle, which are already somewhat reduced by the scanty supply of grass and the exposures of the season. Owing to the climatic conditions prevailing in this section it would be a boon if some of the native plants could be used for fodder when dried. As the salt bush mentioned, *Atriplex argentea*, has been used for this purpose, I included it in our experiment. In regard to the sorghum fodder, two things are to be considered; first, it is necessary to grow it without irrigation and with but little rainfall; the average rainfall of Cheyenne Wells is 15.90 inches; second, the plants will not grow rankly and the fodder would not be used until the latter part of winter or some time during the spring, by which time it is claimed that sorghum fodder will have deteriorated very materially. But even under these conditions one would judge sorghum fodder to be preferable to hay made from the Russian thistle or some of the salt bushes.

The Sub-station at Cheyenne Wells experimented with the growing sorghum for this purpose. The cultural problems lie entirely beyond my province. The sample of sorghum fodder used was grown by this Sub-station, cut when only a few of the plants were advanced enough to mature seed, shocked and preserved in shock until the following spring. The sample was leafy and of an excellent color, and whatever the changes this fodder may have suffered due to its having stood in shock, exposed to the weather of an eastern Colorado winter, it is still representative of the very best sorghum fodder that the people of this section can hope to obtain.

The second series of experiments include the following: Alfalfa hay, native hay, timothy hay, corn fodder, sorghum fodder and salt bush hay.

The sheep used in these experiments were wethers about one year old, so-called Mexican lambs, and represented the stock fed by feeders in this valley. The sheep were rather under-sized but healthy and hardy. They were gentle and their stalls were light and airy, so arranged that we could close them nights and during severe weather. The water given them to drink was heated to from 14 deg. to 20 deg. C., and in cold weather to from 35 deg. to 40 deg., usually to about 30 deg. During this series of experiments the sheep received a small allowance of salt, except with the salt bush hay. The weights of the sheep were taken on the morning of the day the experiments began, before feeding, and on the morning of the day they were turned out of the stalls twelve hours after the last feed.

ALFALFA HAY.

Fodder Fed.—Sheep No. 4.

Weight of fodder received in five days, 4450.5 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.75	11.77	1.62	15.03	30.28	35.55

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4106.00	533.23	72.01	668.12	1346.10	1580.27

Orts, air dried, weighed 320.7 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.32	20.74	1.22	14.93	32.44	25.35

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
323.60	66.51	3.91	47.88	104.03	81.29

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4106.00	523.23	72.01	668.12	1346.10	1580.27
Less orts	323.60	66.51	3.91	47.88	104.03	81.29
Consumed	3782.40	456.72	68.18	620.24	1242.07	1498.98

Feces.

Air dried feces weighed 1485.20 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.68	13.37	3.09	10.99	39.95	25.92

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1386.00	198.51	45.89	163.25	593.34	384.92

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3782.40	456.72	68.18	620.24	1242.07	1498.98
Voided	1386.00	198.51	45.89	163.25	593.34	384.92
Digested	2396.40	258.21	22.29	456.99	648.76	1114.06
Co-efficients or percentages digested	**63.64**	**56.54**	**32.61**	**73.68**	**52.23**	**74.32**

Weight of sheep at beginning of experiment 46.0 pounds.
Weight of sheep at end of experiment 49.0 pounds.

ALFALFA HAY.

Fodder Fed.—Sheep No. 5.

Weight of fodder received in five days, 4450.5 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.75	11.77	1.62	15.03	30.28	35.55

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4106.00	523.23	72.01	668.12	1346.1	1580.27

Orts, air dried, weighed 436.7 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.52	22.10	1.32	19.12	24.44	27.50

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
412.60	96.51	5.76	83.44	106.73	120.01

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4106.00	523.23	72.01	668.12	1346.10	1580.27
Less orts	412.60	96.51	5.76	83.44	106.73	120.01
Consumed	3693.40	426.72	66.25	564.68	1239.37	1460.26

Feces.

Air dried feces weighed 1426.7 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.73	11.77	3.06	10.46	41.72	26.26

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1130.69	167.94	43.65	149.22	595.25	374.61

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3693.40	426.72	66.25	564.68	1239.37	1460.26
Voided	1130.69	167.94	43.65	149.22	595.25	374.61
Digested	2562.71	258.78	22.60	415.48	644.12	1085.65
Co-efficients or percentages digested	**69.39**	**60.64**	**34.11**	**75.58**	**51.97**	**74.35**

Weight of sheep at beginning of experiment 46.0 pounds.
Weight of sheep at end of experiment 49.0 pounds.

ALFALFA HAY.

Fodder Fed.—Sheep No. 6.

Weight of fodder received in five days, 4450.5 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
7.75	11.77	1.62	15.03	30.28	35.55

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4106.00	523.23	72.01	668.12	1346.10	1580.27

Orts, air dried, weighed 229.3 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.45	22.02	1.12	16.78	30.73	23.90

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
216.81	50.49	2.57	38.48	70.46	43.53

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4106.00	523.23	72.01	668.12	1346.10	1580.27
Less orts	216.81	50.49	2.57	38.48	70.46	43.53
Consumed	3889.19	472.74	69.52	629.64	1275.64	1536.74

Feces.

Air dried feces weighed 1718.6 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.82	12.15	3.12	10.86	40.34	26.83

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1601.36	208.83	53.62	186.21	693.31	461.12

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3889.19	472.74	69.52	629.64	1275.64	1536.74
Voided	1601.36	208.83	53.62	186.21	693.31	461.12
Digested	2287.83	263.91	15.91	443.42	582.33	1075.62
Co-efficients or percentages digested	**58.83**	**55.83**	**22.85**	**70.36**	**45.65**	**69.99**

Weight of sheep at beginning of experiment 42.0 pounds.
Weight of sheep at end of experiment 45.0 pounds.

The Average Co-efficients.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 4	**63.64**	**56.54**	**32.61**	**73.68**	**52.23**	**74.32**
Sheep No. 5	**69.39**	**60.64**	**34.11**	**73.58**	**51.97**	**74.35**
Sheep No. 6	**58.83**	**55.83**	**22.85**	**70.36**	**45.65**	**69.99**
Average	**63.95**	**57.67**	**29.86**	**72.54**	**49.93**	**72.89**

If we do not include the coefficient 22.85 found for the fat in the experiment with sheep No. 6, we would still have only 33.34 as the average for sheep Nos. 4 and 5, which is still very much lower than has been found by any other experimenter for any cutting of alfalfa hay. A very little of the hay used in these experiments was slightly mouldy, the rest of the hay was in prime condition and the sample was fair. The highest average coefficient which we find for the fat or ether extract is 33.34, and that actually found for the three sheep is 29.86, while the highest individual coefficient is 34.11. All that has been said concerning the care taken to eliminate analytical errors in the first series of experiments with alfalfa, applies to this, and we believe that we have succeeded in eliminating them.

CORN FODDER.

Fodder Fed.—Sheep No. 1.

Weight of fodder received in five days, 3896.2 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
8.21	9.53	1.55	4.62	29.85	46.24

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
3576.37	371.22	60.36	179.91	1162.12	1802.14

Orts, air dried, weighed 818.6 grams.

Analysis of Orts.

Moisture.	Asn.	Fat.	Protein.	Fibre.	Extract.
6.79	8.49	1.28	2.49	35.02	45.93

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
763.02	69.49	10.47	20.38	286.61	375.91

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	3576.37	371.22	60.36	179.91	1162.12	1802.14
Less orts	763.02	69.49	10.47	20.38	286.61	375.91
Consumed	2813.35	301.73	49.89	159.53	875.51	1426.23

Feces.

Air dried feces weighed 1400.3 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.73	12.63	1.12	7.16	30.16	42.20

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1306.06	176.82	19.74	100.22	422.33	590.94

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	2813.35	301.73	49.89	159.53	875.51	1426.23
Voided	1306.06	176.82	19.74	100.22	422.33	590.94
Digested	1507.29	124.91	30.15	59.31	453.18	835.29
Co-efficients or percentages digested	**53.58**	**41.39**	**60.43**	**37.18**	**51.76**	**57.16**

Weight of sheep at beginning of experiment 47.0 pounds.
Weight of sheep at end of experiment 49.0 pounds.

CORN FODDER.

Fodder Fed.—Sheep No. 2.

Weight of fodder received in five days, 3896.2 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
8.21	9.53	1.55	4.62	29.85	46.24

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
3576.37	371.22	60.36	179.91	1162.12	1802.14

Orts, air dried, weighed 995.6 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.72	7.66	1.30	2.59	35.01	46.72

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
928.7	76.26	12.94	25.78	348.52	465.12

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	3576.37	371.22	60.63	179.91	1162.12	1802.14
Less orts	928.70	76.26	12.94	25.78	348.52	465.12
Consumed	2647.67	294.96	47.42	154.13	813.60	1337.02

Feces.

Air dried feces weighed 1230.4 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.67	13.26	1.19	7.83	29.20	42.00

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1148.34	163.12	14.64	96.34	359.21	516.71

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	2647.67	294.96	47.42	154.13	813.60	1337.02
Voided	1148.34	163.12	14.64	96.34	359.21	516.71
Digested	1499.33	131.84	332.77	57.79	454.39	820.31
Co-efficients or percentages digested	**56.63**	**44.70**	**69.11**	**37.49**	**55.85**	**61.35**

Weight of sheep at beginning of the experiment 46.0 pounds.
Weight of sheep at end of experiment 47.0 pounds.

CORN FODDER.

Fodder Fed.—Sheep No. 3.

Weight of fodder received in five days, 3896.2 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
8.21	9.53	1.55	4.62	29.85	46.24

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
3576.37	371.22	60.36	179.91	1162.12	1802.14

Orts, air dried, weighed 800.0 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.47	7.22	1.26	2.63	37.19	45.23

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
748.24	57.76	10.08	21.04	297.55	362.83

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	3576.37	371.22	60.36	179.91	1162.12	1802.14
Less orts	748.24	57.76	10.08	21.04	297.55	362.83
Consumed	2828.13	313.46	50.28	158.87	864.57	1439.31

Feces.

Air dried feces weighed 1220.2 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.76	14.17	1.29	7.90	26.56	43.32

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1137.72	172.94	15.74	95.73	324.01	528.51

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	2828.13	313.46	50.28	158.87	864.57	1439.31
Voided	1137.73	172.94	15.74	95.73	324.01	528.51
Digested	1690.41	140.52	34.54	63.14	540.56	910.80
Co-efficients or percentages digested	**59.77**	**44.83**	**68.69**	**33.45**	**62.52**	**63.28**

Weight of sheep at beginning of experiment 48.5 pounds
Weight of sheep at end of experiment 49.0 pounds.

Average Digestion Co-efficients of Corn Fodder.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 1	**53.58**	**41.30**	**60.43**	**37.18**	**51.76**	**57.16**
Sheep No. 2	**56.63**	**44.70**	**69.11**	**37.49**	**55.85**	**61.35**
Sheep No. 3	**59.77**	**44.83**	**68.69**	**33.45**	**62.52**	**63.28**
Average	**56.66**	**43.61**	**66.08**	**36.04**	**56.71**	**60.60**

The fodder used in the preceding experiments was obtained from the Farm Department. It was cut August 20, stood in shock until November 22, when it was hauled in and stacked, where it remained till March 10. The fodder was bright, prime fodder. The corn was a variety of dent, and was mature enough to have a few ears so far developed that the corn hardened up while in shock. All of the ears and nubbins were husked out. The corn had been seeded thinly in drills. The ratio of the leaves to the stems was 2-1. The fodder was cut fine, from one-fourth to one-half inch long. The orts consisted wholly of stalks, as the sheep ate all the leaves. We did not succeed in inducing the sheep to eat all the stems, even when they had been ground in a drug mill and moistened.

Jordan and Hall give as maximum, minimum and average digestion coefficients for dent and flint corn fodder (mature):

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Maximum	72.7	52.9	82.0	67.6	79.8	81.2
Minimum	59.8	6.6	64.7	37.9	42.8	63.4
Average	68.2	30.6	73.9	56.1	55.8	72.2

The same authors give the maximum, minimum and average coefficients for dent and flint cornfodder, immature, as:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Maximum	69.8	57.4	79.5	70.5	74.6	74.0
Minimum	52.3	17.7	57.3	24.1	46.1	59.2
Average	63.9	37.2	72.2	51.7	66.0	66.2

The coefficients obtained for our three individual sheep agree very well indeed, but our averages are quite different from those given in the compilation cited. Neglecting the ash and considering the other results, we have the following exhibit of facts relative to the digestibility of corn fodder, with which many experi-

ments have been made, the most of them by Eastern experimenters, and naturally under Eastern conditions.

My first series of experiments gave the following results—corn fodder inmature:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 1	56.43	47.08	48.04	47.46	64.07	54.90
Sheep No. 2	60.28	42.29	45.40	46.07	70.24	60.25
Sheep No. 3	58.98	39.06	44.28	48.62	69.30	57.66
Average	**58.56**	**42.84**	**45.91**	**47.38**	**67.87**	**57.60**

Second series. Corn fodder, grown thinly in drills and mature enough to ripen a few ears:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 1	53.58	41.39	60.43	37.18	51.76	57.16
Sheep No. 2	56.63	44.70	69.11	37.49	55.85	61.35
Sheep No. 3	59.77	44.83	68.69	33.45	62.52	63.28
Average	**56.66**	**43.64**	**66.08**	**36.04**	**56.71**	**60.60**

The coefficients obtained for the individual sheep in the respective series agree as well as could be expected, and while the two series vary greatly, as it is proper that they should, all of the conditions under which the experiments were made being different in every respect. Still the results have a common feature when compared with the results recorded by all other American experimenters, i. e., they are uniformly low. This is, perhaps, most fairly shown by taking the averages, but, as will be noticed upon mere inspection, I might take the minima given by others and my result would still be comparatively low, but, as suggested, the averages may be fairer.

The averages found in Jordan and Hall, "The Digestibility of American Feeding Stuffs," are for dent and flint corn fodder:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Immature	63.9	37.20	72.2	51.7	66.0	66.2
Mature	68.2	30.60	73.9	56.1	55.8	72.2
My first series	58.6	42.84	45.9	47.4	67.9	57.6
My second series	56.7	43.64	66.1	36.0	56.7	60.6

In only one instance does the average found for any of the constitnents given exceed the average given by Jordan and Hall, i. e., the coefficient found for crude fibre. With this exception my coefficients are all low. I will take up this point later, but will remark that in spite of the low coefficients obtained, the animals were gaining flesh, as the three made an aggregate gain of three and a half pounds in the five days. The ration fed was not, in my opinion, such as to permit any unusual portion of it to pass the animal without having been fully acted on by the digestion processes. The amount of dry matter consumed was 2.7 per cent. of the animal's weight, a ratio which is by no means excessive.

TIMOTHY HAY.

Fodder Fed Sheep No. 1.

Weight of fodder received in five days, 4440. grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.49	9.37	2.99	5.62	31.54	43.99

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4151.88	416.03	132.72	249.54	1400.26	1923.64

Orts, air dried, weighed 1269.6 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
4.99	6.97	1.48	5.83	33.20	47.53

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1206.25	88.49	18.79	74.01	421.52	603.42

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4151.88	416.03	132.72	249.54	1400.26	1923.64
Less orts	1206.25	88.49	18.79	74.01	421.52	603.42
Consumed	2945.63	327.54	113.93	175.53	978.74	1320.22

Feces.

Air dried feces weighed 1549.9 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.79	7.84	2.28	5.92	37.26	39.91

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1444.67	121.59	35.33	91.75	577.41	618.52

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	2945.63	327.54	113.93	175.53	978.74	1320.22
Voided	1444.67	121.59	35.33	91.75	577.41	618.52
Digested	1500.96	205.95	78.60	83.78	401.33	702.70
Co-efficients or percentages digested	**50.96**	**62.88**	**68.99**	**47.73**	**41.00**	**53.23**

Weight of sheep at beginning of experiment 47.5 pounds.
Weight of sheep at end of experiment 48.0 pounds.
Daily consumption of dry matter equalled 2.7 per cent of the animals weight.

TIMOTHY HAY.

Fodder Fed Sheep No. 2.

Weight of fodder received in five days, 4440.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.49	9.37	2.99	5.62	31.54	43.99

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4151.88	416.03	132.72	249.54	1400.26	1923.64

Orts, air dried, weighed 1329.4 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.78	6.71	2.14	7.93	37.44	40.00

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1232.53	89.20	28.44	105.45	497.74	531.72

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4151.88	416.03	132.72	249.54	1400.26	1923.64
Less orts	1232.53	89.20	28.44	105.45	497.74	531.72
Consumed	2919.35	326.83	104.28	144.09	902.52	1391.92

Feces.

Air dried feces weighed 1549.7 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.35	6.72	2.06	5.48	39.75	39.64

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1451.30	104.13	31.92	84.92	616.02	614.21

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	2919.35	326.83	104.28	144.09	902.52	1391.92
Voided	1451.30	104.13	31.92	84.92	616.02	614.21
Digested	1468.05	222.70	72.36	59.17	286.50	777.71
Co-efficients or percentages digested	**50.28**	**68.14**	**69.39**	**41.06**	**31.94**	**55.87**

Weight of sheep at beginning of experiment 48.0 pounds.
Weight of sheep at end of experiment 47.5 pounds.
Daily consumption of dry matter equalled 2.7 per cent of the animals weight.

TIMOTHY HAY.

Fodder Fed Sheep No. 3.

Weight of fodder received in five days, 4440.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.49	9.37	2.99	5.62	31.54	43.99

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4151.88	416.03	132.72	249.54	1400.26	1923.64

Orts, air dried, weighed 1893.7 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.26	6.66	1.62	6.11	38.13	42.22

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1794.10	126.15	30.67	115.72	722.01	799.55

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4151.88	416.03	132.72	249.54	1400.26	1923.64
Less orts	1794.10	126.15	30.67	115.72	722.01	799.55
Consumed	2357.78	289.88	102.02	123.82	678.25	1124.09

Feces.

Air dried feces weighed 1208.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.00	8.19	2.57	6.02	36.34	41.08

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1135.52	98.93	31.04	72.72	438.91	496.22

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	2357.78	289.88	102.05	123.82	678.25	1124.09
Voided	1135.52	98.93	31.04	72.72	438.91	496.22
Digested	1222.26	190.95	71.01	51.10	239.34	627.87
Co-efficients or percentages digested	**51.84**	**65.87**	**69.58**	**41.27**	**35.29**	**55.86**

Weight of sheep at beginning of experiment 47.0 pounds.
Weight of sheep at end of experiment 46.0 pounds.
Daily consumption of dry matter equalled 2.2 per cent of animals weight.

Average Digestion Co-efficients for Timothy Hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 1	**50.96**	**62.88**	**68.99**	**47.73**	**41.00**	**53.23**
Sheep No. 2	**50.28**	**68.14**	**69.39**	**41.06**	**31.94**	**55.87**
Sheep No. 3	**51.84**	**65.87**	**69.58**	**41.27**	**35.29**	**55.86**
Average	**51.03**	**65.63**	**69.32**	**43.35**	**36.08**	**54.99**

The hay fed was not the same as in the former experiment. The sheep were younger and of a different breed, and the conditions of air, sunlight and general attention to the comfort of the animal were more favorable than in the former experiment. All of these facts should be taken into consideration in comparing the results. As both samples of hay were obtained in the Denver market, I cannot be more than morally certain that they were of about the same age, bnt I really entertain no doubt on this point. If we may judge by the amount of orts left, the hay used in the first experiment was more palatable to the sheep than that used in the second. The total amount of orts left by the three sheep in the first experiment was 60 grams, while they aggregated 4493.0 grams in the second.

The individual taste of one of the sheep was very marked in the second series, as it seemingly ate none of the timothy heads, all of which seemed pretty mature.

I will restate the results obtained in the first experiment that the differences may be the more easily observed:

The Digestion Co-efficients of Timothy Hay, First Series.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 3	56.83	34.62	26.01	57.51	56.33	62.72
Sheep No. 4	59.52	32.94	35.85	58.70	57.56	64.53
Sheep No. 8	53.77	34.86	33.79	58.91	49.94	60.79
Average	56.71	34.14	31.88	58.37	54.61	62.80

Jordan and Hall give the digestion coefficients for timothy hay before or in bloom as follows:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Maximum	65.7	48.2	60.8	60.4	62.1	71.8
Minimum	55.9	41.8	51.5	51.1	56.6	57.4
Average	60.7	44.2	58.4	56.8	58.8	64.3
Timothy hay past bloom.						
Average	53.4	30.3	51.9	45.1	47.1	60.4

The coefficient found for the fat or ether extract in the second series seems to be an exception, being much higher than the maximum given by Jordan and Hall for this constituent of the hays, but the coefficients found for the three sheep are in much closer agreement than we usually find to be the case in this work. With this exception we find in both series a very marked tendency toward lower coefficients than other experimenters have found—a result which was specifically mentioned in connection with the coefficients found for corn fodder.

NATIVE HAY.

Fodder Fed Sheep No. 4.

Weight of fodder received in five days, 4394.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.13	10.64	3.13	6.98	31.38	42.74

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4168.56	467.54	137.53	306.71	1388.12	1878.23

Orts, air dried, weighed 839.5 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.22	9.84	3.05	6.09	31.34	44.46

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
795.68	82.60	25.60	51.12	263.01	373.23

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4168.56	467.54	137.53	306.71	1388.12	1878.23
Less orts	795.68	82.60	25.60	51.12	263.01	373.23
Consumed	3372.88	384.94	111.93	255.59	1125.11	1505.00

Feces.

Air dried feces weighed 1643.8 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.03	12.92	5.12	5.78	27.99	42.16

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1544.68	212.31	84.16	95.01	406.19	693.04

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3372.88	384.94	111.93	255.59	1125.11	1505.00
Voided	1544.68	212.31	84.16	95.01	406.19	693.04
Digested	1828.20	172.61	27.74	160.58	664.92	812.96
Co-efficients or percentages digested	**54.20**	**44.84**	**22.10**	**62.83**	**59.09**	**54.02**

Weight of sheep at beginning of experiment 50.0 pounds.
Weight of sheep at end of experiment 50.5 pounds.
Daily consumption of dry matter equalled 3.0 per cent of the animals weight.

NATIVE HAY.

Fodder Fed Sheep No. 5.

Weight of fodder received in five days, 4394.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.13	10.64	3.13	6.98	31.38	42.74

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4168.56	467.54	137.53	306.71	1388.12	1878.23

Orts, air dried, weighed 954.5 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.06	7.69	2.99	5.41	33.32	45.53

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
906.21	73.40	28.53	51.63	318.01	434.51

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4168.56	467.54	137.53	306.71	1388.12	1878.23
Less orts	906.21	73.40	28.53	51.63	318.01	434.51
Consumed	3262.35	394.14	109.00	255.08	1070.11	1443.72

Feces.

Air dried feces weighed 1766.4 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.91	13.42	5.17	5.48	28.12	41.90

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1642.09	237.02	91.32	96.79	496.78	740.14

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3262.35	394.14	109.00	255.08	1070.11	1443.72
Voided	1642.09	237.02	91.32	96.79	496.78	740.14
Digested	1620.26	157.12	17.68	158.29	573.33	703.58
Co-efficients or percentages digested	**46.60**	**39.76**	**16.22**	**62.06**	**53.58**	**48.74**

Weight of sheep at begining of the experiment 50.0 pounds.
Weight of sheep at the end of the experiment 50.5 pounds.
Daily consumption of dry matter equalled 2.9 per cent of the animals weight.

NATIVE HAY.

Fodder Fed Sheep No. 6.

Weight of fodder received in five days, 4394.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.13	10.64	3.13	6.98	31.38	42.74

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4168.56	467.54	137.53	306.71	1388.12	1878.23

Orts, air dried, weighed 803.3 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.23	9.93	2.60	6.09	31.40	44.65

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
761.29	79.76	20.88	48.93	252.22	358.62

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4168.56	467.57	137.53	306.71	1388.12	1878.23
Less orts	761.29	79.76	20.88	48.93	252.22	358.62
Consumed	3407.27	387.78	116.65	257.78	1135.90	1519.61

Feces.

Air dried feces weighed 1783.0 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.96	12.41	5.02	5.48	29.29	41.84

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1676.78	221.21	89.50	97.71	522.26	746.01

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3407.27	387.78	116.73	257.78	1135.90	1519.61
Voided	1676.78	221.21	89.50	97.71	522.26	746.01
Digested	1730.49	166.57	27.23	160.07	613.64	773.60
Co-efficients or percentages digested	**50.79**	**42.95**	**23.33**	**62.09**	**54.02**	**51.09**

Weight of sheep at the beginning of the experiment 45.0 pounds.
Weight of sheep at the end of the experiment 47.5 pounds.
Daily consumption of dry matter equalled 3.3 per cent of the animals weight.

The Average Digestion Co-efficients for Native Hay.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 4	**54.20**	**44.84**	**22.10**	**62.88**	**59.09**	**54.02**
Sheep No. 5	**46.60**	**39.76**	**16.22**	**62.06**	**53.58**	**48.78**
Sheep No. 6	**50.79**	**42.95**	**23.33**	**62.09**	**54.02**	**51.09**
Average	**50.53**	**42.52**	**20.55**	**62.33**	**55.56**	**51.30**

I have stated in connection with the first series of experiments that I know of no data really applicable to this, which we designate as native hay.

The coefficients found for these two hays with which I have experimented agree fairly well, with the exception of those found for the ether extract, which are very far apart. The hays were composed of different grasses and were grown in localities twenty-two miles apart. The average coefficients found in the first series of experiments were as follows:

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
59.78	43.32	47.09	60.90	61.36	62.01

This hay seems to have been a decidedly more digestible one than that used in the second series. The grass constituting the greater part of that used in the second experiment was Colorado blue stem, *Agropyron tenerum*.

SORGHUM FODDER.

Fodder Fed Sheep No. 1.

Weight of fodder received in five days, 4441.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.75	8.17	1.55	5.80	23.26	55.47

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4185.68	371.21	68.83	258.51	1055.45	2019.45

Orts, air dried, weighed 482.3 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.37	10.19	1.29	4.97	28.43	48.75

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
457.95	38.95	4.93	19.00	108.61	186.31

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4185.68	371.21	68.83	258.51	1055.45	2019.45
Less orts	457.95	38.95	4.93	19.00	108.61	186.31
Consumed	3727.73	332.26	63.70	239.51	946.84	1833.14

Feces.

Air dried feces weighed 1698.8 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.80	11.46	1.28	8.48	28.16	43.82

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1583.24	194.61	21.74	144.02	478.34	744.47

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3727.73	332.26	63.70	239.51	946.84	1833.14
Voided	1583.24	194.61	21.74	144.02	478.34	744.47
Digested	2144.49	137.65	41.96	95.49	468.50	1088.67
Co-efficients or percentages digested	**57.53**	**41.43**	**65.87**	**39.87**	**49.38**	**59.39**

Weight of the sheep at the beginning of the experiment 53.5 pounds.
Weight of the sheep at the end of the experiment 50.5 pounds.
Daily consumption of dry mattr equalled 3.1 per cent of the animals weight.

SORGHUM FODDER.

Fodder Fed Sheep No. 2.

Weight of fodder received in five days, 4441.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.75	8.17	1.55	5.80	23.26	55.47

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4185.68	371.21	68.83	258.51	1055.45	2019.45

Orts, air dried, weighed 890.8 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
8.09	8.35	1.25	4.55	25.14	52.62

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
818.74	74.38	11.13	40.53	223.92	468.73

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4185.68	371.21	68.83	258.51	1055.45	2019.45
Less orts	818.74	74.38	11.13	40.53	223.92	468.73
Consumed	3366.94	296.83	57.70	217.98	732.53	1550.72

Feces.

Air dried feces weighed 1502.1 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.42	11.15	1.47	8.38	28.18	44.40

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1405.65	167.41	22.08	125.81	423.35	666.91

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3366.94	296.83	57.70	217.98	732.53	1550.72
Voided	1405.65	167.41	22.08	125.81	423.35	666.91
Digested	1961.29	129.42	35.62	92.17	309.18	883.81
Co-efficients or percentages digested	**58.22**	**43.60**	**61.73**	**42.28**	**42.21**	**56.99**

Weight of the sheep at the beginning of the experiment 49.5 pounds.
Weight of the sheep at the end of the experimnt 47.0 pounds.
Daily consumption of dry matter equalled 3.0 per cent of the animal's weight.

SORGHUM FODDER.

Fodder Fed Sheep No. 3.

Weight of fodder received in five days, 4441.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.75	8.17	1.55	5.80	23.26	55.47

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
4185.68	371.21	68.83	258.51	1055.45	2019.45

Orts, air dried, weighed 375.6 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
8.26	10.54	1.27	4.70	24.76	50.47

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
344.58	39.58	4.77	17.65	92.99	185.22

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	4185.68	371.21	68.83	258.51	1055.45	2019.45
Less orts	344.58	39.58	4.77	17.65	92.99	185.22
Consumed	3841.10	331.63	64.06	240.86	962.46	1834.23

Feces.

Air dried feces weighed 1648.4 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.66	11.57	1.44	8.69	28.77	41.07

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
1550.61	169.81	21.14	127.61	422.42	608.93

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	3841.10	331.63	64.06	240.86	962.46	1834.23
Voided	1550.61	169.81	21.14	127.61	422.42	608.93
Digested	2290.49	161.82	42.92	113.25	540.04	1225.30
Co-efficients or percentages digested	59.63	48.80	67.00	47.02	56.11	66.80

Weight of the sheep at the beginning of the experiment 56.0 pounds.
Weight of the sheep at the end of the experiment 53.0 pounds.
Daily consumption of dry mattr equalled 3.0 per cent of the animal's weight.

Average Co-efficients for Sorghum Fodder.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 1	57.53	41.43	65.87	39.87	49.38	59.39
Sheep No. 2	58.22	43.61	61.73	42.28	42.21	56.99
Sheep No. 3	59.63	48.80	67.00	47.02	56.11	66.80
Average	58.46	44.61	64.87	43.06	49.23	61.06

There are but few recorded experiments upon the digestibility of sorghum fodder. The following is quoted by Jordan and Hall from the publications of the North Carolina Station—two experiments with sorghum fodder (pulled from Back African and Collier canes):

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
First, with goat	59.89	17.64	47.14	59.46	64.88	62.51
Second, with cow	66.29	41.31	46.25	62.20	75.88	66.55

There is a record of two experiments by the Texas Station, but the fodder was cut in dough state and fed green. This fact would make but little difference, provided the fodder was cut at the same period of development and the fodder retained its feeding qualities unmodified by keeping, especially when exposed to alternations of freezing and warm weather. These experiments were made with cows and gave the following results:

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
	73.3	43.8	81.6	56.7	75.0	78.2
	73.1	39.5	81.3	51.1	74.0	78.7
Average	73.2	41.6	81.4	53.4	74.5	78.3

The coefficients are very varying, but represent different fodders. I used one cut in the latter part of September and kept, as the most of our fodders are kept, in shock until used. The time of my experiment also corresponded to that at which this fodder would be used, so the results represent as nearly as possible the value of this fodder to the stockmen of the eastern part of the state. Considering that the North Carolina experiments were made with pulled fodder, blades and tops, while mine were made with the whole plant, it seems that the results obtained in my experiments

have really lost nothing of their general value, from the fact that the experiments were made with regard to special conditions.

I am inclined to doubt the claim which is sometimes urged against this fodder, that it changes rapidly, losing its feeding qualities. One must admit, however, that the coefficients given by the Texas Station experiments show a much higher degree of digestibility than either those of the North Carolina Station or my own. My experiments show that a large amount of dry matter was eaten per thousand of live weight, i. e., 30 to 31 pounds. The animals ate it freely enough, but each of the animals lost weight while feeding upon it. The aggregate loss was 7.5 pounds in five days; so that neither the coefficients found nor the weights of the animals at the end of the experiments indicate any great value for such sorghum fodder.

The animals fed upon it well, as the amount left as orts as well as the large amount of dry matter consumed indicate, and, so far as we could observe, they suffered no inconvenience from their being kept upon it as an exclusive diet for 12 days.

The variety of sorghum was Minnesota Early Amber, grown on sandy loam; sown May 10, cut September 15, stood in shock until following March. Weight of crop not given.

SALT BUSH. Atriplex Argentea.

Fodder Fed Sheep No. 4.

Weight of fodder received in five days, 6422.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.32	19.28	1.46	9.73	27.33	36.38

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
6080.38	1238.62	93.76	624.82	1755.75	2368.23

Orts, air dried, weighed 1547.0 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.24	15.61	1.07	7.23	39.57	30.28

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract
1450.47	241.41	16.55	111.82	612.12	468.43

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	6080.38	1238.62	93.76	624.82	1755.75	2368.23
Less orts	1450.47	241.41	16.55	111.82	612.12	468.43
Consumed	4629.91	997.21	77.21	513.00	1143.67	1899.80

Feces.

Air dried feces weighed 2655.1 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.53	10.53	1.32	6.27	40.44	34.91

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2481.78	279.51	35.04	166.41	1073.14	926.81

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	4629.91	997.21	77.21	513.00	1143.67	1899.80
Voided	2481.78	279.51	35.04	166.41	1073.14	926.81
Digested	2148.13	717.70	42.17	346.59	70.53	972.99
Co-efficients or percentages digested	**46.40**	**71.97**	**54.62**	**67.56**	**6.02**	**51.21**

Weight of the sheep at the beginning of the experiment 52.0 pounds.
Weight of sheep at the end of the experiment 50.0 pounds.
Daily consumption of dry matter equalled 3.9 per cent of the animal's weight.

SALT BUSH. Atriplex Argentea.

Fodder Fed Sheep No. 5.

Weight of fodder received in five days, 6422.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.32	19.28	1.46	9.73	27.33	36.38

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
6080.38	1238.62	93.76	624.82	1755.75	2368.23

Orts, air dried, weighed 761.0 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.84	13.96	1.16	7.18	40.17	31.69

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
716.56	106.23	8.83	54.63	305.61	241.11

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	6080.38	1238.62	93.76	624.82	1755.75	2368.23
Less orts	716.56	106.23	8.83	54.63	305.61	241.11
Consumed	5363.82	1132.39	84.93	570.19	1450.14	2127.12

Feces.

Air dried feces weighed 3102.1 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
6.36	10.18	1.37	6.49	38.66	37.01

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2904.89	315.71	42.50	201.34	1227.48	1148.11

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5363.82	1132.39	84.93	570.19	1450.14	2127.12
Voided	2904.89	315.71	42.50	201.34	1227.48	1148.11
Digested	2458.93	816.68	42.43	368.85	222.66	979.01
Co-efficients or percentages digested	**45.84**	**72.12**	**49.95**	**64.69**	**15.35**	**46.03**

Weight of sheep at the beginning of the experiment 58.0 pounds.
Weight of sheep at the end of the experiment 52.0 pounds.
Daily consumption of dry matter equalled 4.1 per cent of the animal's weight.

SALT BUSH. Atriplex Argentea.

Fodder Fed Sheep No. 6.

Weight of fodder received in five days, 6422.0 grams.

Analysis of Fodder.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.32	19.28	1.46	9.73	27.33	36.38

Fodder Constituents Fed, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
6080.38	1238.62	93.76	624.82	1755.75	2368.23

Orts, air dried, weighed 870.1 grams.

Analysis of Orts.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.57	14.88	0.99	6.42	42.32	29.82

Fodder Constituents Contained in the Orts, in Grams.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
821.46	129.41	8.61	55.86	368.24	259.41

Fodder Constituents Consumed, in Grams.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Fed	6080.38	1238.62	93.76	624.82	1755.75	2368.23
Less orts	821.46	129.41	8.61	55.86	368.24	259.41
Consumed	5258.92	1109.21	85.15	568.96	1387.51	2108.82

Feces.

Air dried feces weighed 2979.6 grams.

Analysis of Feces.

Moisture.	Ash.	Fat.	Protein.	Fibre.	Extract.
5.58	10.87	1.36	6.34	40.61	35.24

Fodder Constituents Voided.

Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
2813.48	326.62	40.49	188.71	1369.10	1049.27

Fodder Constituents Digested.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Consumed	5258.92	1109.21	85.15	568.96	1387.51	2108.82
Voided	2813.48	326.62	40.49	188.71	1369.10	1049.27
Digested	2445.44	782.50	44.66	380.25	48.41	1059.55
Co-efficients or percentages digested	**46.50**	**70.55**	**52.45**	**66.83**	**3.49**	**50.24**

Weight of the sheep at the beginning of the experiment 47.5 pounds.
Weight of the sheep at the end of the experiment 47.0 pounds.
Daily consumption of dry matter equalled 4.9 per cent of the animal's weight.

The Average Co-efficients of Salt Bush. Atriplex argentea.

	Dry Matter.	Ash.	Fat.	Protein.	Fibre.	Extract.
Sheep No. 4	**46.40**	**71.97**	**54.62**	**67.56**	**6.02**	**51.21**
Sheep No. 5	**45.84**	**72.12**	**49.95**	**64.69**	**15.35**	**46.03**
Sheep No. 6	**46.50**	**70.55**	**52.45**	**66.83**	**3.49**	**50.24**
Average	**46.25**	**71.55**	**52.34**	**66.36**	**8.29**	**49.16**

No data on the subject of the fodder value of the native salt bushes have come to my knowledge, so there are no results with which to compare these obtained with *Atriplex argentea.*

This salt bush is not to be mistaken for the Australian salt bush, *Atriplex semibaccata*, which plant differs materially from *Atriplex argentea.* The Australian salt bush has, I believe, been recommended by the California Station as a forage plant in alkali soils. I have made two preliminary tests with this plant, with results showing it to be better as it grows with us than the native silvery salt bush, but not a real good fodder. It probably would be a good plant for trial in the eastern part of the state where this silvery one grows. The Australian salt bush is an annual with us, which seeds itself abundantly.

The average digestion coefficients as found in these experiments with the silvery salt bush present some rather striking features. The coefficient for the dry matter is low, but it is evident that this must be the case when we observe that the crude fibre, constituting over one-quarter of the weight of the hay, is so good as indigestible.

The coefficient found for the nitrogen free extract is also low, but approaches the coefficients found for this constituent in hays, being, in fact, higher than in some of them. The ash in this plant is very abundant and its coefficient of digestion, 71.55,

is very high. The effect of this fodder upon the animals was very marked. The animals seemed to suffer no inconvenience, they looked as bright and contented as usual and chewed their cuds freely. There was no laxative, but a very marked diuretic action observed. I regret that I was not provided with facilities for collecting the urine. It would be interesting to know the amount voided and its nitrogen content. The water drunk daily by the same sheep varied from 1.5 to 4.5 pounds when fed native hay and a little salt, but this amount of water was increased to 10.5 to 15.0 pounds when they were fed on the salt bush and salt was withheld. Sheep No. 5 drank from 1.5 to 3.0 pounds of water when fed on native hay, but drank from 12 to 14 pounds daily when fed on the salt bush; but No. 6 drank the maximum quantities of water, from 13 to 15 pounds. There is no proof that the excessive amount of urine voided was due to the specific action of any substance contained in the plant, and it seems rather more probable that the large amount of saline matter taken into the system, 782.59 grams, a trifle over five ounces daily, provoked an intense thirst, as indicated by their drinking from three to eight times the amount of water usually drank by these individual animals, which flooded the system and had to be voided.

The weather at the time, the first week in June, was fine, the temperature of the water drank 13 deg.–14 deg. C.

Had the weather been cold and stormy and the water which the animal drank very cold, the results would have been less favorable than those observed. It must be kept in mind that this hay was put up for the purpose of feeding it to animals, already reduced in flesh and vitality, to take them over stormy periods. The general result of the experiment is not encouraging.

Some of the fodder constituents, the protein, for instance, show a comparatively good coefficient and there is a fair amount of it contained in the fodder. The same is true of the nitrogen free extract. The coefficient for the fat is good and compared with other plants there is a fair amount of it, but these good features of the salt bush as a fodder plant are offset by this thirst provoking and diuretic effect, whether the latter is consequent upon the former or not. I omit the composition of the ash in the hay and the feces, but may take it up in a later bulletin.

This bulletin is already longer than I desired it to be, and as each set of experiments summarizes itself I will not recapitulate the results here.

This bulletin will be followed very shortly by another, in which I shall take up some subjects omitted in this, i. e., the digestibility of the various extracts, alcoholic, aqueous, etc., together with the digestibility of the pentosans occurring in these fodders.

All of these hays and fodders have been cured and preserved

under Colorado conditions, and the animals used were the average grade of sheep fattened by the hundred thousand in this valley. Our results are as representative of our fodders and conditions as they can be made.

The coefficients found are not only lower than those usually given, but are lower than those given by investigators experimenting under very similar conditions. I have exercised every care to obtain correct results, and I believe that the coefficients of our fodders actually have a lower value than is usually given for the same fodders elsewhere.

Our fodders are seldom preserved under cover, but in stacks or shocks out of which they usually come as green, bright, attractive looking hays and fodders. They have, however, been exposed to our changes of temperature, our dry air and continuously strong light.

I believe that the results recorded in this bulletin are very close to the facts and would tentatively suggest that the coefficients of digestion for our hays and fodders are lower than the coefficients shown by the same fodders elsewhere. I do not know the reason for this, but believe that the manner of preserving the fodders, together with our climatic conditions, may account for it.

SUMMARY.

The average coefficients of digestibility found for corn fodder—a variety of dent corn—sown thickly and cut quite immature were: Dry Matter, 58.56; Ash, 42.84; Fat, 45.91, Protein, 47.38; Crude Fibre, 67.87; Nitrogen Free Extract, 57.60. The average coefficients given by Jordan and Hall for the immature fodder are: Dry Matter, 63.9; Ash, 37.2; Fat, 72.2; Protein, 51.7; Crude Fibre, 66.0; Nitrogen Free Extract, 66.2.

The second experiment with corn fodder, dent corn, drilled thinly in rows, cut August 20, some ears matured corn which were husked out before cutting to be fed, gave the following: Dry Matter, 56.66; Ash, 43.64; Fat, 66.08; Protein, 36.04; Crude Fibre, 56.71; Nitrogen Free Extract, 60.60. Jordan and Hall give the following coefficients for dent and flint corn (mature): Dry Matter, 68.2; Ash, 30.6; Fat, 73.9; Protein, 56.1; Crude Fibre, 55.8; Nitrogen Free Extract, 72.2.

It will be noticed that our coefficients are lower than the quoted ones, which are averages.

The average coefficients obtained for alfalfa hay in the first series of experiments were: Dry Matter, 52.04; Ash, 45.65; Fat, 90.85; Protein, 66.69; Crude Fibre, 47.76; Nitrogen Free Extract, 56.69.

The sample of hay used in this experiment contained an unusually low percentage of ether extract, 0.80, and was not a first-class hay, neither was it a decidedly inferior hay.

The second experiment in which a prime, first cutting hay was used gave the following: Dry Matter, 63.95; Ash, 57.67; Fat, 29.86; Protein, 72.54; Crude Fibre, 49.93; Nitrogen Free Extract, 72.89. The animals used in the first experiment were mature sheep probably 4 years old; those used in the second were young sheep, so-called Mexican lambs, about 1 year old.

The average digestion coefficients of first cutting alfalfa hay, which I obtain by using all the data available at this time, not including my own, are: Dry Matter, 61.00; Ash, 51.58; Fat, 53.81; Protein, 74.40; Crude Fibre, 47.11; Nitrogen Free Extract, 72.49.

There is here a substantial uniformity except in the case of the coefficient for the fat or ether extract, which we hold to be of little or no value, which is emphasized by the extreme results obtained in the first series of experiments. See remarks at conclusion of first series of experiments.

We mean to indicate by the negative sign that there was 90.85 per cent. more fat, ether extract, in the feces than in the hay eaten.

Native hay is seldom composed of the same mixture of grasses even if cut from the same ground, but in different years. It is therefore difficult to obtain comparable samples.

We obtained for a sample grown in the neighborhood of Fort Collins the following coefficients: Dry Matter, 59.78; Ash, 43.32; Fat, 47.09; Protein, 60.90; Crude Fibre, 61.36; Nitrogen Free Extract, 62.01; and for another sample grown in the Box Elder Valley about 23 miles north of the Poudre Valley the following: Dry Matter, 50.53; Ash, 42.52; Fat, 20.55; Protein, 62.33; Crude Fibre, 55.56; Nitrogen Free Extract, 51.30. The hay used in the second series of experiments seems to have been a decidedly less digestible one than that used in the first experiment; it represented a different mixture of grasses, the former consisting largely of Colorado blue stem.

Jordan and Hall give for meadow hay, with which our "native hay" is possibly more nearly comparable than with any other fodder, the following: Dry Matter, 54.3; Ash, 29.4; Fat, 44.7; Protein, 63.4; Crude Fibre, 54.5; Nitrogen Free Extract, 55.9.

Timothy hay is grown in large quantity in some of our mountainous districts and is of superior quality. We obtained as digestion coefficients for this hay, in the first series: Dry Matter, 56.71; Ash, 34.14; Fat, 31.88; Protein, 58.37; Crude Fibre, 54.61; Nitrogen Free Extract, 62.80. In the second series: Dry Matter, 51.03; Ash, 65.63; Fat, 69.32; Protein, 43.35; Crude Fibre, 36.08; Nitrogen Free Extract, 54.99.

These samples differed as much from one another as any two samples which we might purchase in the market would be likely to differ, as the second was purchased two years subsequent to the first and both would be properly classed as prime timothy hay.

Jordan and Hall gave the average digestion coefficients for timothy hay before and in bloom as: Dry Matter, 60.7; Ash 44.2; Fat, 58.4; Protein, 56.8; Crude Fibre, 58.8; Nitrogen Free Extract, 64.3. For timothy hay past bloom: Dry Matter, 53.4; Ash, 30.3; Fat, 51.9; Protein, 45.1; Crude Fibre, 47.1; Nitrogen Free Extract, 60.4.

The differences are marked in some instances but the agreement is as great as we have any right to expect.

The native hays are highly esteemed as feed for horses, commanding the same price in the market as timothy hay. If there is any choice the native hay receives the preference, while both are prefered before alfalfa, especially for livery and road animals. The results with the sheep are interesting in this connection. The fodders were fed alone, there was no mixed ration, but the sheep made a gain of 3 pounds each when fed alfalfa, the timothy scarcely maintained their weight, one sheep gained ½ pound, one sheep lost ½ pound and one lost 1 pound. The native hay makes a somewhat better showing as a fodder for sheep, two sheep gained ½ pound each, while the third one gained 2½ pounds in five days.

The result which will appeal to the public as most striking, so far as a digestion experiment can be depended upon to indicate the value of a fodder, is that obtained with the corn fodder. This fodder was not shredded, but simply cut as fine as we could conveniently cut it with a hand cutter, neither was it prepared in any manner, being fed dry, and yet the sheep showed a gain of 2 pounds, 1 pound and ½ pound respectively in the five days and the dry matter consumed per 100 weight of animal was less than of the other fodders.

The average digestion coefficients found for sorghum is for a fodder held until the spring of the year. The question which I had in mind when I undertook this particular experiment was what can our ranchmen in the eastern part of the state grow as a fodder to feed their cattle during the severe storms of late winter and spring when it is often necessary to tide the animals over trying periods. Sorghum promises to yield them as much fodder under their conditions as any other forage plant. The fodder, if it is used at all, must be shocked and kept till late winter or spring. It might have greater value if fed in the fall or early winter, but the experiments with it gave disappointing results so far as its feeding value was concerned, the sheep losing 3, 2.5 and 3 pounds respectively in five days.

The average digestion coefficients obtained were: Dry Matter, 58.46; Ash, 44.61; Fat, 64.87; Protein, 43.06; Crude Fibre, 49.23; Nitrogen Free Extract, 61.06.

There are but few recorded digestion experiments with sorghum fodder. An experiment with a goat gave the following: Dry Matter, 59.88; Ash, 17.64; Fat, 47.14; Protein, 59.46; Crude Fibre, 64.88; Nitrogen Free Extract, 62.51.

The salt bush atriplex argentea used by ranchmen in the eastern part of the state yields digestion coefficients as follows: Dry Matter, 46.25; Ash, 71.55; Fat, 52.34; Protein, 66.36; Crude Fibre, 8.29; Nitrogen Free Extract, 49.16.

These coefficients, that for crude fibre and consequently that for the dry matter excepted, are quite favorable, but as a fodder for sheep it is a failure if the weights of the sheep after their 12 days feeding on salt bush can be relied upon. The sheep were weighed at the beginning and end of their last 5 days feeding on this fodder, when we found that they had lost ½, 2 and 6 pounds respectively in this time.

This fodder provoked an intense thirst, the animals drinking from 10½ to 15 pounds of water a day and voiding an immense amount of very ill-smelling urine.

These same animals drank from 1½ to 4½ pounds of water daily when fed on other fodders.

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Bulletin 94. (Technical Series No. 6) **December, 1904.**

The Agricultural Experiment Station

OF THE

Colorado Agricultural College.

REPORT OF THE ENTOMOLOGIST.

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BY

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T. D. A. Cockerell.

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FORT COLLINS, COLORADO.

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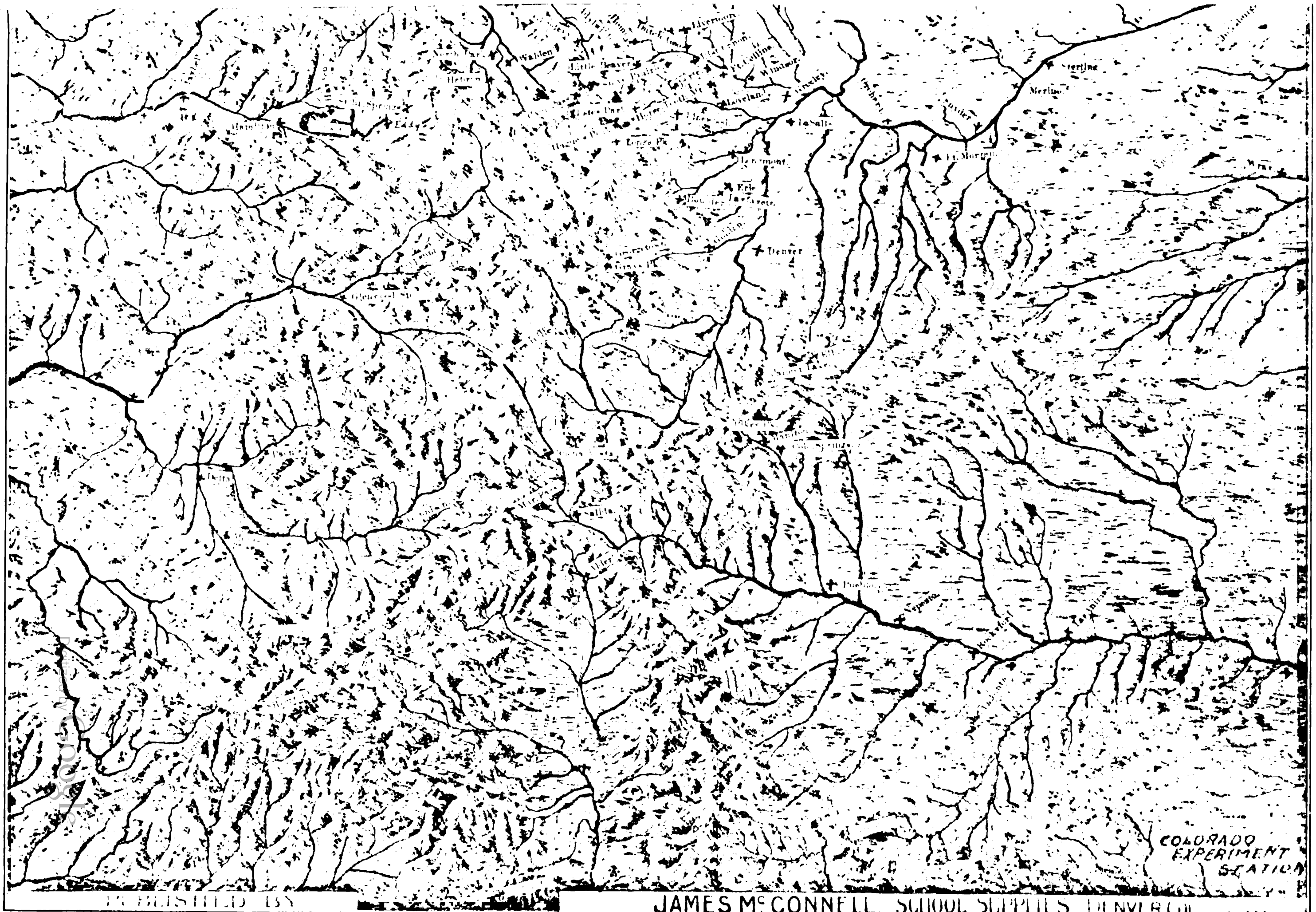
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Some of the More Important Insects of 1903.

By CLARENCE P. GILLETTE.

GRAIN BUG.

The Grain Bug (*Pentama sayi Stal.**)

[Pl. I. Fig. H.]

Early in August complaints came to the Experiment Station of a large green bug that was doing extensive injuries to grain and other crops in Montezuma county. Mr. S. A. Johnson was sent to investigate the trouble. He went directly to Cortez and was greatly assisted in the work by Mr. P. S. Taylor of that place. The following is an extract from Mr. Johnson's report of what he found:

"Mr. Taylor took me to a number of fields of wheat and oats that had been injured by the green plant-bug. He says that the bugs appeared in great numbers in the fields of grain when they were just heading out where they accumulated upon the heads and seemed especially to suck the juices of the forming kernels. As the grain would reach maturity the bugs would migrate to other fields where the grain was not so far advanced. At present the attack is less severe, much of the grain having matured but still in most fields four or five strokes of an insect net will collect a handful of the bugs and many of the insects are upon the lower portions of the plants and upon the ground. The injuries in the grain fields are indicated by the presence of the blasted heads that have few or no kernels in them and which have ripened and turned white prematurely (see plate II. Fig. A.)

"The injury to oats was very severe. In some cases entire fields of grain appeared to be destroyed. Often the heads were blasted from the punctures of the bugs before they appeared above the leaf sheath.

"The insect seems to be a rather general feeder. It was reported upon first cutting of alfalfa, and upon sunflowers, sage and garden vegetables, especially peas. But very few were obtained

*Determined for us by Mr. E. P. VanDuzee; also by Mr. Otto Heidemann, through the kindness of Dr. L. O. Howard.

sweeping alfalfa with the net and it seemed probable that those taken in this manner might have come from the weeds. In case of peas and beans the pods were chiefly attacked and the juices were extracted from the seeds within. A peculiar effect upon the peas was that the punctures introduced or prepared a way of entrance for a fungus which soon rendered all the seeds unfit for use.

"No one remembered having seen the insect in injurious numbers before and some believed that the insect had migrated into their midst from farther down the river where it was reported that the bugs were still more abundant, and where they did some injury last year."

The following letter giving an estimate of injuries in Montezuma valley was written by Mr. P. S. Taylor, Oct. 21, 1903, in reply to my letter of inquiry:

"The bugs first appeared in the valley about the 20th of May, coming from the southwest for three days in succession. These lighted mostly on alfalfa fields where they deposited their eggs, which hatched about two weeks later.

"The bugs remained on the alfalfa until the first cutting of hay was made. Then, (about the first part of July) they left the hay fields going to adjoining wheat fields where for a time they sucked the sap from the wheat plants. As soon as grain formed in the heads the bugs bored into it, drawing their nourishment from the soft grain. This they continued until the wheat either hardened or was killed.

"Leaving the wheat they attacked oat fields in August, working in the same manner as on the wheat. But the damage that was done to oats was not nearly so great as that done to wheat.

"By the first of September nearly all the bugs had disappeared and so far as I could determine there were no eggs deposited after the first lot in June. The damage was done almost entirely in the lower part of the valley, on an area of 725 acres where an average yield for the past eight years was 35 bushels per acre, or a total of 25,375 bushels. The yield of the past season on the same number of acres was 15 bushels per acre, or a total of 10,875 bushels. This would show a shortage of 14,500 bushels and a money loss at present prices of over thirteen thousand dollars.

"Some fields of grain were entirely destroyed while others were injured only in spots."

Respectfully yours,
P. S. TAYLOR.

The following is an extract from a letter received from Mr. M. V. B. Page, of Fruita, Colo., dated August 6:

"I am sending you samples of a bug that is destroying crops of all kinds but more especially potatoes, by sucking the sap from the stems of the plants. They are upon oats as well. They come in patches and then spread over the fields. I first discovered them in a small patch of ten acres of early potatoes a week ago and now they are all over the patch. I find no small ones; all seem to be of the size of the sample sent."

This bug is a close relative of *Liodcrma uhleri* which was reported by Saunders in Bulletin 57 of the South Dakota Experiment Station and the habits of the two insects seem much alike. The species that has been so abundant in the southwestern portion of Colorado the past summer is generally distributed over the mountainous portions or the State and has frequently been taken

from native plants for the College and Station collections. Mr. C. R. Jones, a special student in entomology here, found this bug common above timberline at Silverton, Colo., the past summer where he was collecting. Specimens are seldom taken at Fort Collins.

The insect is single brooded.

There was a great advantage this year in having grain ripen early. Fall wheat escaped the injuries almost entirely.

GRASSHOPPERS.

The destructive grasshoppers (locusts) which are usually very numerous over a great portion of the agricultural section of the State were comparatively few in number this year except in limited sections. The previous year was marked by unusually severe grasshopper depredations and the small number of these insects the present year is probably due to the prevalence last year of the native grasshopper disease, *Empusa grylli* On the other hand, there has been very little of this disease among the grashoppers the past summer and fall.

The Australian Grasshopper Fungus, was experimented with again this year. Several tubes of the fungus were sent directly from the Colonial Bacteriological Institute of the Cape of Good Hope through the kindness of the director, Dr. Alexander Edington. The cultures were received in an excellent condition and were used in the field and in our breeding cages but in no case were we successful in killing any of the grasshoppers as far as we could determine. As this is the second year that we have worked with this disease without obtaining any apparent results, I can see no reason to encourage Colorado farmers to hope for relief from grashopper depredations through the use of the African grasshopper fungus (*Mucor sp.*)

A new grasshopper remedy known as "Criddle mixture" has been reported very efficient for the destruction of grasshoppers in Manitoba. It consists of a mixture of fresh horse manure, salt and Paris green which is distributed about the fields where the grasshoppers are numerous. In our experiments the ingredients were used in the following proportions:

Fresh horse manure	40 quarts.
Barrel salt	2 quarts.
Paris green	1 quart.

The preparation was repeatedly used in breeding cages and in field tests. In no case were the results very encouraging so long as there was green food obtainable. Poisoned alfalfa leaves and poisoned bran were used in comparison with the Criddle mixture and of the three the bran seemed most efficient. None of these preparations gave results that were very satisfactory.

Mr. Conrad Schaffer, an extensive and intelligent farmer living at Deuel, Colorado, decided to try the Criddle mixture and induced several of his neighbors to join with him and make a thorough test. In a verbal report to the writer on October 20, Mr. Schaffer said the mixture did but little good. He said he had much better results with a mixture of bran and Paris green that was moistened with just enough refuse syrup from a beet sugar factory to make the mixture adhere in small balls. These balls of poisoned bran were distributed about 20 feet apart along potato rows and in other places where the grasshoppers were abundant.

CUTWORMS.

The Army Cutworm (*Chorizagrotis auxilaris.**)

[Pl. I. Fig. A. B. C. D.]

which is usually as numerous as all other species put together in northern Colorado, occured in more than its usual abundance last spring. The moths have a strong propensity for getting into buildings whether there are lights inside or not. It is a common thing for these moths to appear in large numbers upon the insides of windows during May and June. The moths also conceal themselves among the leaves of trees during the day time. The abundance of the moths was especially remarkable during the summer of 1902 and many inquiries were received at the Station concerning them. A stick or a stone thrown into a tree when they were most numerous would often cause hundreds to fly out for a few seconds then they would return. They were such an annoyance about lamps in houses that the occupants of the home would blow out the lights and go to bed just to get away from the nuisance. So that the unusual cutworm invasion of the past spring was only the sequel of the abundance of moths the preceding summer.

This is the species treated by Dr. Wilcox in Bulletin 17 of the Montana Experiment Station. It is a native of the Rocky Mountain region. I have found the moths not uncommon in this State,near to timber-line under the loose bark of stumps.

Specimens of the spring brood of moths have been taken at the Station between April 16 and July 10,and are usually most abundant about the first of June. The fall brood has been taken from September 13 to October 12. A queer circumstance in connection with my studies of this moth is, I have never been able to find fully developed ova in the females of the first brood though hundreds have been dissected and examined. In the great majority of cases there has been no indication of ova in any stage of develop-

**Chorizagrotis auxilaris* having priority, I have included with it forms commonly determined as *introferens* and *agrestis* because in a larger series there seems to be every gradation between the three forms and because they always occur together and rise and fall together in numbers so far as my experience has gone. The specimens in the collection were determined by Dr. J. B. Smith; also by Mr. Otto, Heidemann through the courtesy of Dr. L. O. Howard.

ment. The females taken in the fall have, almost without exception, contained fully formed ova. Neither have I ever known the fall brood to be noticeably adundant, only occasional specimens being taken.

About the first of May there were several newspapers of the State reporting the presence of some kind of army worm in millions in different localities. On April 31 I went to Fort Morgan where extensive injuries from such an insect were reported. In company with Senator W. A. Drake, several farms were visited and the injuries of the worm noted. In one instance the Chapman brothers had sowed alfalfa seed in the spring of 1902 and secured a good stand and then the alfalfa suddenly disappeared, from some unknown cause,for a distance of four or five rods along the border of the field adjoining wild land. The strip was re-seeded May 28 and a good stand secured which grew thriftily throughout the summer. The past spring alfalfa in this field made a good start again and at the time of my visit it was rapidly disappearing. An examination showed the cause to be cutworms.

Another field of the previous year's seeding belonged to Mr. Burnett and seemed to be perfectly bare, but on examination the little alfalfa stocks could be seen everywhere, but the leaves and tender new shoots had all been eaten down b; the worms.

On Senator Drake's farm a large field of virgin soil had been plowed and sowed to barley early in the spring. The barley came up nicely all over the field and then suddenly disappeared. To one driving past this field there was no evidence that there had been a green thing growing there a few days before. I went into the field and could not find a single spear of barley but upon digging down from one to two inches could find the stubs of the young plants and the worms. The senator told me later that the barley did not appear again so that the fields had to be replanted.

Other fields were visited and it soon became evident that there were two types of injuries. In some cases the fields of grain and alfalfa were attacked about the borders only, while in others the injuries seemed equally distributed throughout the field. A little inquiry revealed the fact that in all cases where the virgin soil had been plowed in the spring and seeded the injuries were distributed throughout the field, but where the virgin soil had been plowed the previous fall or summer, the cutworm injuries were only noticed about the borders of the fields and only those borders that were adjacent to wild land. Fort Morgan is in a grazing region and the ground is pretty well covered with a mixture of gramma and buffalo grasses which are evidently among the native food plants of this cutworm, in fact the worms were found feeding upon these grasses.

About the first of May reports began to come in of extensive injuries to sugar beets from cutworms. As near as could be determined not less than four or five hundred acres of beet land in Northern Colorado had to be re-seeded this year because of the ravages of cutworms. Next to virgin soil, the fields that were in grain the previous season seem to have suffered most and barley seems to have been the grain that attracted the moths for the deposition of their eggs far more than any of the others.

On May 29, in company with Mr. H. H. Griffin, one of the field agents for the Fort Collins Sugar Company, I visited Mr. John Hice's farm near Fort Collins. He partially plowed a field of barley stubble late last fall and then finished plowing in the spring and put the field in to beets. The beets on the fall-plowing were in very good condition, but upon the spring plowing they were so badly taken by the worms that it was decided to re-plow the entire field and seed again. At that date, May 20, the worms were fast disappearing and many pupæ could be found and fields seeded after this date were not seriously attacked by the worms. The spring was unusually late this year so that it is probable that in an ordinary season the cutworms would do little injury to beets after the 10th or 15th of May, or after the moths begin to appear upon the windows or about the lights of our houses. May 20th was the first date we noticed them upon our windows the past summer.

On May 30, Mr. S. A. Johnson went to Aurora, a suburb of Denver, to investigate cutworm injuries and was aided in the work by Mr. H. Rauchfuss, who had written the Station concerning the injuries by the worms. Mr. Johnson found the worms mostly full fed or in the pupa state. The worms were pupating about two inches beneath the surface in vertical burrows with the head of the chrysalis towards the mouth of the burrow. The earthen cells at the bottom of the burrow were quite firm though they could be crushed without difficulty between the thumb and fingers. A quantity of the worms were brought into the laboratory and placed in breeding cages for the purpose of rearing the moths and it was found that nearly half of the worms were parasitized. The majority of the parasitized individuals seemed to be entirely eaten out beneath the skin and to be packed full of minute pupæ of a species of *Copedosoma*. In one instance 1705 of the adults issued from a single worm. See Plate I. Fig. D. Two Ichneumon parasites (*Ichneumon longulus* and *Amblyteles subrufus*) were also bred from the worms.

Two pupæ and worms brought into the laboratory the last of April began appearing as moths June 26.

Plowing during the summer or fall and keeping the ground clean of all vegetation until winter will give almost perfect pro-

tection against these cutworms unless there are adjacent infested lands from which the worms may migrate into the borders of growing crops.

The clandestine cutworm, (*Noctua clandestina.*)

A dark brown, almost black species, without conspicuous markings upon the wings, is also common each year in the north-eastern portion of Colorado, at least. It is a little later than the preceding species, the moths appearing about the lamps as those of *Chori-azgrotis auxilaris* are becoming scarce. I have never known it to be nearly so numerous as that species.

LEAF ROLLERS.

The Fruit-Tree Leaf-Roller (*Cacœcia argyrospila Walk.*)
[Pl. I. Figs. E and F.]

This insect in company with *Cacœcia semiverena*, the boxelder leaf-roller, has an interesting history in Colorado. Thirteen years ago both were destructively abundant in Northern Colorado in the vicinity of Fort Collins and Greeley. Their numbers have gradually grown less in that portion of the State until the past year or two, when they have not occured in sufficient numbers to attract attention much north of Denver, while they are very destructive to the foliage of fruit and box-elder trees in that city and in the vicinity of Colorado Springs.

Many of the Tortricid moths vary greatly in color markings so that it is often impossible to distinguish between species without rearing the moths from single patches of eggs. There has been so much of this variation in the moths that I have been grouping under the name *C. argyrospila* that I decided to rear a few "families" from separate batches of eggs. Six egg-batches were placed in separate cloth sacks and each sack tied over a limb of a plum tree on April 23, when two of the patches, (numbers 1 and 5 of the following diagram) were beginning to hatch. These sacks were frequently examined and when the larvæ were nearly grown the contents of each sack were brought into the laboratory and placed in a separate breeding cage and the transformations noted until the moths all appeared. The records of the six cages are given as follows:

SUMMARY OF SIX BREEDING-CAGE RECORDS UPON TRANSFORMATIONS OF CACŒCIA ARGYROSPILA.

Cage numbers	1	2	3	4	5	6
Began Hatching	April 23	did not hatch.		April 23		
First Pupa	June 2			June 2	June 2	June 2
Last Pupa	June 13			June 17	June 11	June 20
First Moth	June 15		June 13	June 13	June 13	June 13
Last Moth	June 25		June 30	July 1	June 19	June 29

As egg-patches 3 and 4 were not hatching when placed in the sacks but gave pupæ and moths as early as any, it is to be presumed that they were not more than a day behind those in cages 1 and 5. This would make the shortest time from hatching of the egg to emergence of adult moth 50 days and the longest time 68 days. It is rather remarkable that in the four cases noted the first pupation occured on the same date, June 13. This would indicate about 11 days as the ordinary time spent in the pupa stage.

Moths bred from the same batch of eggs vary in color from a dark rusty red with only one conspicious pale yellow patch in the middle of the costal margin of the anterior wing to a light straw yellow with only faint indications of the rusty coloration outlined in a very light rusty brown. There is one typical pattern of the dark markings however, which can be traced through all the specimens. Figs. E. and F. Plate I. show twelve of these moths in two rows. All in the front row were bred from a single patch of eggs. Those in the second row are from two other patches. That all the moths from the five cages are of the same species is proven by the fact that each group has one or more moths that are exactly like some in all the other groups.

Experiments for the destruction of eggs. Several laboratory tests were made to determine the effect of certain insecticides upon the egg-patches early in the spring. They resulted as follows:

Kerosene emulsion that was one-third kerosene was applied to 6 egg patches. None of the eggs hatched.

Kerosene emulsion that was one-fourth kerosene was applied to 7 egg patches. One patch hatched well, one partially, 5 not at all.

Kerosene emulsion that was one-sixth kerosene was applied to 6 egg-patches. From one patch two larvæ emerged and from 5 none hatched.

Crude petroleum was applied to 5 egg-patches, and none hatched.

Whale-oil soap, 1 pound to 1 gallon of water was applied to 8 egg patches. Three hatched well, 2 partially and 3 did not hatch at all.

Whale-oil soap, 1 pound to 2 gallons of water, was applied to 7 egg-patches; three hatched well, one hatched about half, two hatched a very few, one did not hatch at all.

Whale-oil soap, one pound to four gallons of water was applied to six egg-patches; two hatched well and four did not hatch at all.

Lime salt and sulfur was applied to five patches; four hatched well and one did not hatch at all.

Whitewash composed of lime one pound, water two quarts, was applied to eight patches; one patch hatched well, five patches hatched about half of the larvæ and two hatched a very few.

Lime wash in the proportion of two pounds to three gallons of water was applied to seven egg-patches all of which hatched well.

Arsenite of lime in which there was about one pound of arsenic to 100 gallons of water was applied to six patches of eggs; one patch hatched well, three hatched about half the eggs, two hatched but very few.

Arsenate of lead in the proportion of a pound to five gallons was applied to 12 patches of eggs; five patches hatched well, two hatched about half of the eggs, two hatched a very few larvæ and three hatched none.

From these tests we are encouraged to think that crude petroleum and the stronger emulsions may be used quite successfully for the destruction of the eggs before the leaves appear in the spring, but whale-oil soap, whitewash, lime-sulfur-and-salt, and the arsenical poisons do not give much promise. Our whale-oil soap was very hard and probably not of good quality.

The Choke-Cherry Leaf-Roller (*Cenopsis testulana Zell.*)
Pl. I. Fig. G.

This leaf-roller is occasionally quite abundant among the small choke-cherry bushes in the foothills near Fort Collins where it builds extensive and rather loose webs. It is also an extremely variable species. In some the fore wings are pale yellowish brown almost without dark markings, in others the fore wings are a deep and rather dark rust-brown without any signs of light markings while a majority have sulfurous yellow back-ground more or less heavily marked with rust-brown. See the third or lower row of moths in Plate I. Fig. G.

BEET WEB-WORM (*Loxostege sticticalis Linn.*)*
[Pl. I. Fig. I.]

On July 11th the writer was called to investigate the injuries being done by a horde of small striped caterpillars to onions and cabbages on a farm near Fort Collins. On visiting the farm in question it was found that in the center of a large field there was a small area, perhaps an acre, that was above irrigation and which, being neglected, had grown up to lamb's quarter. Upon these weeds the worms had fed until the plants were brown and dry. The worms then left the dead weeds and marched out like an invading army into the cultivated crops of onions and cabbages which they were devouring very rapidly at the time of my visit.

*Determined by Mr. Coquillett through kindness of Dr. L. O. Howard.

Two days later, word came to the Station that some worm had appeared in great numbers in many of the fields of young beets. A ride through the infected area in company with Mr. Charles Evans, manager of the Fort Collins Beet Growers' Association, revealed the fact that nearly if not quite all of the injuries from worms were to fields that had been plowed in the spring. In most of these fields considerable alfalfa was growing at the time of our visit.

To avoid such injuries as the above, do not allow lamb's quarter (*Chenopodium sp.*) to grow in proximity to other crops, and, in case alfalfa ground is to be put in to cultivated crops it would be better to plow the previous fall, but in any case keep the ground sufficiently cultivated to keep down any growth of alfalfa which might attract the moths for the purpose of egg-laying early in the season.

THE GOOSEBERRY FRUIT-WORM (*Dakruma Convolutella*) (?)

The gooseberry fruit-worm has become a serious pest, especially to currants, along the foot hills of the eastern slope in this State. It is not uncommon to hear that this insect has destroyed the greater portion of the crop. It also feeds freely upon a common wild currant, *Ribes aurium*, which grows in the foothills, a fact which adds much to the difficulty of keeping the pest in check.

PLANT LICE (*Aphididæ.*)

Several species of plant lice were extremely abundant again during the past summer. Various insecticide substances have been used experimentally against these lice both in the egg and in the later stages and a press bulletin, No. 20, entitled "Plant Lice and their Remedies," written by Mr. S. Arthur Johnson has been issued by the Station.

The apple plant louse (*Aphis pomi*) has been extremely abundant and quite destructive to small trees in some localities. For several years past there have been many trees, particularly small ones, that have had many of their small limbs literally blackened with eggs of this insect. Such trees are common in the orchards of Northern Colorado during the present fall. I have observed such trees for several years and have never known more than a very small fraction of the eggs to hatch in the spring. In fact in some cases I have been unable to find that any of the eggs upon a tree have hatched. I am confident that not more than one egg in a thousand hatched in the vicinity of Fort Collins last spring and yet by the middle of June the lice were common in orchards and gradually increased in numbers so that from the middle of July on through the summer the lice on the apple trees of this section were exceedingly numerous. I have never seen any evidence that

this louse has an alternate food-plant in Colorado, at least it is continuously upon apple,and pear trees from the opening of the leaves in spring until the eggs have been deposited in October and November.

The green plum louse,(*Aphis pruni*,) the black cherry louse, (*Myzuz cerasi*,) the boxelder louse (*Chaitophrous negundinis*,) the snow-ball louse (*Aphis viburni*) and the woolly louse (*Schizoneura lanigera*) of the apple, were all of them specially abundant. The beet-root louse (*Tychea brevicornis*) has been reported by Mr. P. K. Blinn, field agent for the Station in the Arkansas Valley, as quite generally distributed in the beet fields in the vicinity of Rockyford and as attacking the roots of many weeds. He reports a louse that seems to be this species as very abundant and quite injurious to the common garden purslane. One beet field of eight acres near Fort Collins, investigated by Mr. Johnson, has been badly infested by this louse and, apparently, the crop has suffered considerably from it.

A full report upon the results obtained from the use of insecticides for the destruction of the lice and their eggs will be given in a bulletin later, after farther tests have been made. I may say here that we seem to have been entirely successful in destroying eggs of the lice with strong applications of kerosene emulsion, crude petroleum or whale-oil soap, made early in the spring.

FALSE CHINCH-BUGS (*Nysius minutus and N. californicus*).

These two species of false chinch-bugs are abundant in Colorado and their combined attacks upon mother beets in the Arkansas valley make it almost impossible to grow beet seed there. Mr. P. K. Blinn, writing under date of June 29, 1903, said he had just collected in one hour's time 20 pounds of these bugs from a patch of mother beets by brushing the insects into a dish held in the hand. Mr. Blinn also reported radishes, and mustard, planted near the beets as trap crops, of no value as the bugs were as abundant on the fields of beets as on the trap crops. He also stated that mother beets grown in a field surrounded by oats were not injured by the bugs. These bugs seem partial to plants of the mustard and goose-foot families and I do not remember to have seen them attacking any of the grasses. It is possible that any of the grains would afford barriers that would be rather effectual in excluding them. Wild mustard is a favorite food-plant for these false chinch-bugs. About nine-tenths of the specimens received from Mr. Blinn from beets were (*N. minutus*.)

Some have thought these insects to be the chinch-bug of the prairie states farther east, but such is not the case.

WESTERN WHEAT-STEM MAGGOT, (*Pegomyia cerealis* n. sp.*)

On the 5th of last May complaint came to this office that a wheat field that was looking all right ten days before had, for some reason, died down badly. Mr. Johnson went to examine the field and returned with a quantity of wheat stems with maggots in their centers. There were ten acres in the field and the injuries were so severe that it was decided that all would have to be plowed under, which was done, and the field planted to sugar beets. The field had been sown to wheat for three years in succession and had been fertilized heavily with barnyard manure the past fall and sowed to winter wheat which grew but little in the fall but which made a fine stand in the spring.

The maggots burrow down the centers of the stems and feed where the latter are most tender, an inch or two beneath the surface of the ground. At the time of examination, May 5, many light colored dipterous pupæ were found an inch or two beneath the surface close to the plants upon which they had been feeding. These pupæ brought into the laboratory began giving flies June 6. The early appearance of pupæ in the field makes it seem likely that the eggs may have been laid the previous fall. If this was not the case, the flies must have emerged very early in the spring.

DESCRIPTION.

The maggots are dirty yellowish white in color and measure between 6 and 7 mm. in length by 1.5 to 1.75 mm. in diameter. At the small or anterior end the two jaws show distinctly and at the posterior end the two spiracles are black and above them is a shining black plate or chitinous piece which terminates in two short stout spines. The puparium is like the maggot in length and thickness, it is straw-yellow at first but darkens rapidly as the time for the emergence or the fly draws near. The black plate and spines of the maggot also show plainly and the extreme anterior end is blackened.

The Adult Flies. Female: length about 5.5 mm. exclusive of ovipositor. Color of head and body rather uniform light gray, set with large and small black bristles that arise, each from a small black spot. Eyes dark reddish brown, naked, separated in front by a space nearly equal to the diameter of an eye; antennæ black, the aristæ also black and slightly plumose to the tips. Color of head like that of thorax except for a slight golden tint upon the face. There are five moderately stout bristles in a row parallel with the inner margin of the compound eye on either side and another row of about 20 of these bristles along the posterior border of each eye, the two at the upper angle of the eye being larger than the others. On the thorax there may be distinguished one median and, on either side, two lateral darker stripes which are quite distinct, and upon each of which a row of stout black bristles arises. Scuttelum with four setæ, two very stout ones near the tip and one not so large near each posterior angle. Abdomen rather thickly set with stout black setæ of moderate size, the largest ones arising from near the posterior margin of the segments. Femora cinereous like the body except at the knees where they change to light amber which is the color of all the tibias; the tarsi of all the legs are deep black. The wings are hyaline, tegulæ and sub-tegulæ small and nearly equal and amber in color, as are all the large veins.

*Specimens submitted to C. W. Johnson were referred to Mr. Coquillett, who determined them, "Near *Pegomyia ceptorum*, but apparently distinct."

The males differ from the females in being of a dark cinereous brown color. The femora are also of the same color and the tibiæ are much darker than in the female. The eyes are very much larger being subattingent in front of the ocelli.

Described from nine males and ten females bred from stems of winter wheat.

The injuries of the fly seem to have been confined to the one field. Mr. S.A. Johnson and Mr. Fred Bishopp examined a large number of fields of winter wheat in the vicinity of Fort Collins but in no case did they find farther injuries by this insect.

The summer and fall habits of this fly are unknown.

A wing of this fly is shown in Fig. C., Pl. II.

Aspidiotus forbesi. A card from Prof. T. D. A. Cockerell, of Colorado College,states that he has found this scale abundant upon a bush of *Cercocarpus parvifolius* growing upon a hillside at Colorado City. This is a matter of sufficient importance to warrant mention of the fact in this report. It seems to be the first record for the species in Colorado.

(Explanation of plates.)

Plate I. A, B, C, three forms of the army cutworm moth (*Chorizagrotis auxilaris;*) D, two living cutworms, a chrysalis, a dead parasitized cutworm and two earthen cells of the same species; E, moths of *Cacœcia argyrospila* (fruit-tree leaf-roller), all bred from one patch of eggs to show variation in markings; F, moths of the same species selected from specimens bred from two patches of eggs; G, choke-cherry leaf-roller (*Cenopis testulana* Zell.), all from one tent showing variation in color; H, Grain-bug, (*Pentatoma sayi* Stal), and wheat kernels shrunken from attack of the bug, also two plump kernels for comparison; I, two larvæ of web-worm (*Loxostege sticticalis* Linn.)

Plate II. A, head of oats blasted from attacks of grain-bug (*Pentatoma sayi*), only three developed kernels; B, apple injured and deformed from application of too strong spray of Paris green; C, wing of western wheat stem-maggot (*Pegomyia cerealis*).

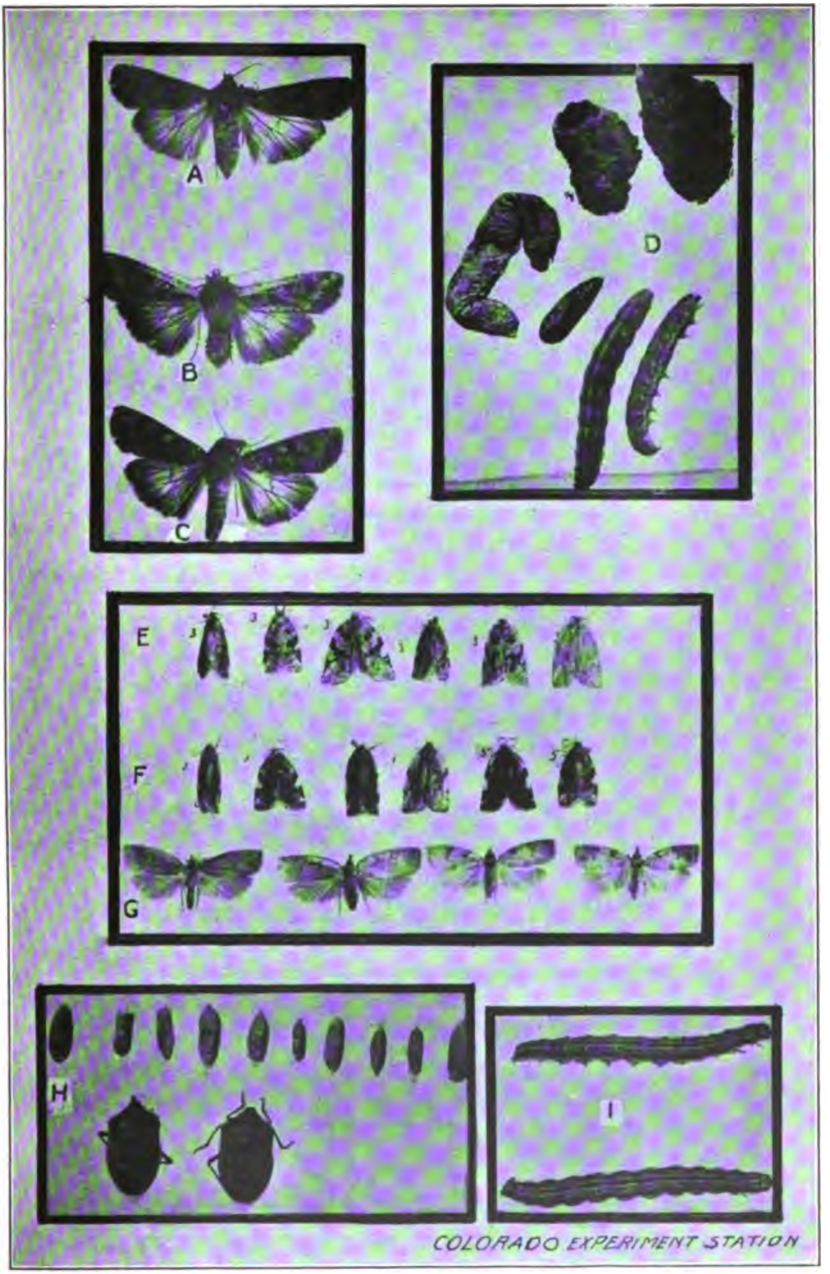

PLATE I.

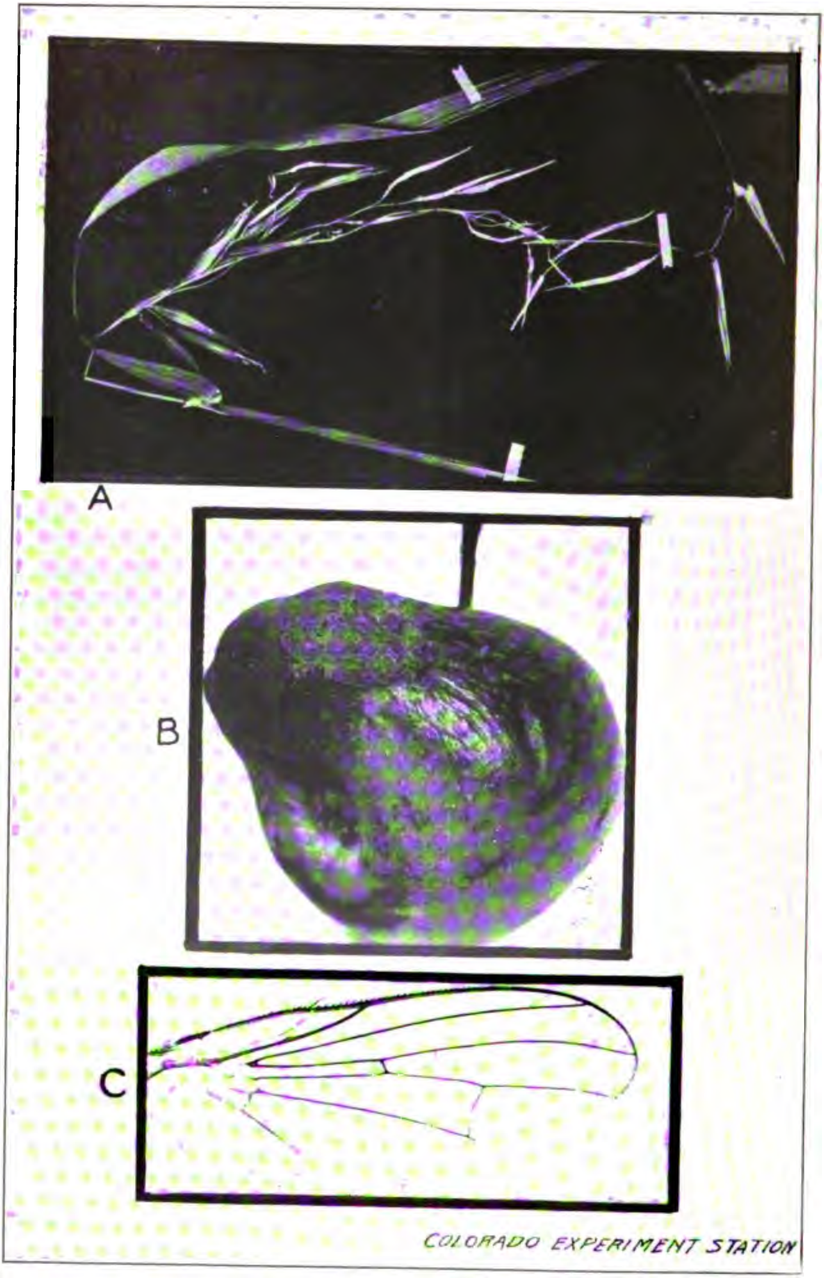

PLATE II.

Annotated List of Colorado Orthoptera

From Material in the Collections of the Colorado Agricultural College and Agricultural Experiment Station.

PART I.

Including Families Forficulidae, Blattidae, Mantidae, Phasmidae and Acridiidae

BY CLARENCE P. GILLETTE.

INTRODUCTION.

Since coming to Colorado about thirteen years ago, the writer has done what he could to make the rich and varied insect fauna of the State known to the world. First, the Cynipidæ were published upon in the *Canadian Entomologist* and in *Entomological News* during the years 1892, '93 and '94. Then Bull. 31, "A Preliminary List of the Hemiptera of Colorado," by Gillette and Baker, was published by the Experiment Station in 1895. In 1898 Bull. 43 was issued giving a list of the Lepidoptera in the College collection with the accessions notes upon them and also giving descriptions of a few new Jassidæ from the State; and the same year the writer prepared a monograph of the "American Leaf-hoppers of Subfamily Typhlocybinæ" which appeared in Vol. XX of the Proc. of the National Museum which included much Colorado material. When Prof. E. D. Ball came to this department as first assistant in 1897 he had already become a writer upon the family Jassidæ and was encouraged to continue his systematic work with this group, with a special view of working up the Colorado fauna, and his articles since that time have added much to our knowledge of Colorado Hemiptera. Mr. E. S. G. Titus wrote his thesis for the degree of M.Sc. upon "Colorado Bees," a bound copy of which is in the College library; and Mr. Titus also wrote numerous articles treating of Colorado bees that were published in the *Canadian Entomologist*. Our entire College collection of Colorado Coleoptera were sent to Prof. Wickham to be used by him in making out his list of Colorado Coleoptera which he published in the *Canadian Entomologist*. Many other papers have appeared from the pens of other entomological workers in which they report upon insects

from the collection of the Colorado Agricultural College and the present paper is another attempt to add to the existing knowledge of the insect fauna of the State. I hope to follow this paper at no distant date with another giving our records upon the remaining families of the order Orthoptera.

It is hoped that the present paper will be found fairly free from errors in determinations. There are still a few species of Acridiidæ not reported because of uncertain identifications and it is probable that, in a few instances, I have included under one name forms that have been considered distinct but which I could not separate except from differences in size or coloration.

BROODS.

All of our records point to one conclusion, and that is that all the species here reported are probably single-brooded.

The number of species reported in this paper are:

Forficulidæ	0
Blattidæ	5
Mantidæ	5
Phasmidæ	2
Acridiidæ	133
Total	145

DISTRIBUTION AND BARRIERS.

There are almost no cases where sharp lines of limitation in this State shut in the distribution of a species. The Continental Divide, and the line made by the sudden breaking of the eastern plains into the foothills and canons of the eastern slope, come nearest to being such barriers; and a few species seem rather closely confined to the area lying above timberline upon the mountain ranges. As a general rule, species that occur over the eastern plains also occur for some distance into the mountainous region but they seldom range higher than 7,000 or 8,000 feet, and many of the plains species occur but a very short distance in the hills. On the other hand mountain species that are common at 9,000 and 10,000 feet altitude are seldom found outside the foothills. Some species occurring abundantly above timber-line may be found all the way to the base of the eastern line of foothills, and *Blattella germanica*, that thrives so well at the sea shore, is equally prolific and aggressive in eating houses at mines located above timberline in the mountains. There are very few species except those that follow in the wake of civilization, that occur upon both the eastern and western slopes of the Continental Divide. A few species from the south and east have found their way up the Arkansas valley into the southeastern portion of the State that we have not found elsewhere, and several species occurring in the Platte valley of the

northern plains region we have not found occuring in the valley of the Arkansas.

The frontice piece is a map giving the main river systems and water sheds of Colorado with the points named where our collections have been made. Upon page 20 I have given a list of the places where collecting has been done, with their altitudes, and with each species I have given all the localities from which it has been taken by us. The reader will thus be able to make out the distribution of such species so far as determined by our records.

ACKNOWLEDGMENTS.

DETERMINATION OF SPECIES.

The Blattidæ here reported have been determined by Prof. Lawrence Bruner or by comparison with examples named by him. The Mantidæ and Phasmidæ have been determined by Professor Bruner, A. N. Caudell or E. D. Ball. The entire collection of Tettiginæ has been through the hands of Prof. Albert P. Morse and are reported as named by him. The remainder of the Acridiidæ have been named very largely by comparison with examples of the various species that were determined for the College by Prof. Bruner or Dr. S.H. Scudder, to whom doubtful and unknown species have been referred. The more readily determined species have been named by E. D. Ball or the writer. All errors are chargable to me, as I have worked over the entire collection during the past year, adding many species and many new records and changing many names. Prof. Morse has also determined several species of Trimerotropis and Spharagemon for me.

COLLECTORS.

The collection upon which this report is based has been accumulated during the past thirteen years as the result of the efforts of many helpers. An examination of 1,500 entries upon the Accessions Book shows that about 50 per cent. of the records are from collections and observations made by E. D. Ball, about 25 per cent. by the writer, and the remaining 25 per cent. by others, most prominent among whom are S. A. Johnson, E. S. G. Titus, E. P. Taylor, F. C. Bishopp and C. F. Baker. I have also received several species from Prof. T. D. A. Cockerell from the vicinity of Colorado Springs and Pike's Peak.

The original plan was to publish this report in joint authorship with Prof. E. D. Ball who was, at the time, my first assistant; but after his appointment to the Chair of Animal Biology in the Agricultural College of Utah, this plan had to be abandoned. I wish specially to acknowledge my obligations to Prof. Ball for the large

amount of work which he did in collecting material and data and making determinations preliminary to the preparation of this report.

The photographic reproduction of the topographical map of Colorado shown in this report is used with the permission of the "Continental School Supply Company" of Denver who own the original map.

PAPERS.

I am under special obligations to Professor Lawrence Bruner, and Professor T. D. A. Cockerell for permission to publish their papers describing Colorado insects in this report.

LOCALITIES AND THEIR APPROXIMATE ALTITUDE.

Akron (G)	4,650	Grand Junc'n (G)	4,594	Montrose (G)	5,811
Alder (G)	8,500	Gray's Peak (G)	10,000	Nepesta (B)	4,400
Alamosa (B)	7,540	Greeley	4,637	New Castle (G)	5,562
Alma	10,240	Gunnison	7,685	North Park	8,500
Antonito	7,889	Gypsum (G)	6,325	Orchard (B)	4,591
Bald Mountain	8,500	Hague's P'k (S)	11,000	Ouray (G)	7,706
Boulder (G)	5,300	Hamilton (J)	6,400	Palisades (G)	4,741
Buena Vista (B)	7,967	Hayden (J)	6,800	Palmer Lake	7,237
Cameron Pass (B)	10,000	Hebron (J)	8,500	Pagoda (J)	6,500
Canon City (G)	5,343	Holly (B)	3,400	Paonia (G)	5,500
Cerro Summit (G)	7,968	Home (B)	9,000	Pinewood (B)	8,000
Chama (N M.)	7,863	Idylwilde (J)	9,000	Pueblo (B)	4.668
Claremont (G)	3,650	Julesburg	3,456	Rico (B)	8,737
Colorado Springs	6,000	La Fayette (G)	5,179	Ridgway (Jo)	7,500
Cortez (J)	7,000	La Junta	4,061	Rifle	5,310
Craig (J)	6,500	Lamar	3,600	Rist Canon	5,500
Delta (G)	4,980	La Salle	4,663	Rocky Ford	4,177
Denver	5,200	Laporte	5,200	Salida (G)	7,050
Dolores (J)	6,957	Las Animas (B)	3,900	Silverton (Jo)	9,224
Durango	6,520	Lay (J)	6,163	Snyder (B)	4,160
Dutch George's (B)	7,000	Leadville (G)	10,200	Steamboat Spr'gs	7,300
Eddy (G)	7,000	Little Beaver	9,000	Sterling	3,920
Elbert (G)	6,710	Livermore	6,000	Stove Prairie	7,500
Erie (G)	8,179	Lizard Head (B)	10,200	Timnath	4,950
Estes Park (G)	8,000	Long's Peak (G)	11,000	Trinidad	5,980
Fort Collins	5,000	Loveland (G)	5,000	Walden (J)	8,500
Fort Morgan (B)	4,263	McCoy (G)	7,300	Ward (B)	10,000
Fruita (G)	4,500	McElmo (G)	6,800	Wheat Ridge	5,300
Georgetown (G)	8,476	Manitou (G)	6,200	Windsor (G)	4,900
Glendevy (J)	9,000	MarshallPass (G)	10,856	Wolcott (G)	6,976
Glenwood Sp. (G)	5,758	Maybell (J)	6,000	Wray (B)	3,500
Golden (G)	5,700	Merino (B)	4,021	Yuma (G)	4,128

The altitude given in each case is that of the town or place itself. The grasshoppers referred to the different places were often taken at much greater altitudes. Silverton, for example, has an altitude of 9,224 feet but the insects referred to Silverton were taken on a mountain near by at an altitude of over 12,000 feet. This will account for my giving altitudes farther on in this

paper, for the occurrence of some of the species much higher than the altitude of any of the stations where the species was taken.

NOTE—Names of places followed by the capital (B) were collected in by Prof. E. D. Ball only; those followed by (J) were collected in by Mr. S. A. Johnson only; those followed by (S) were collected in by Dr. J. W. Skinner only; those followed by (Jo) were collected in by Mr. Charles Jones only, and those followed by (G) were collected in by the writer only.

Family FORFICULIDÆ.

We have not taken a representative of this family within the State.

Family BLATTIDÆ.

BLATTELLA Caudell.

germanica Linn. Specimens in the College collection are from a boarding house in Ft. Collins and from a boarding house at a mine near Silverton at an altitude of 12,000 feet, where they where very numerous in both instances,and a single specimen from a hotel at Leadville.

NYCTOBORA Burmeister.

holosericea Klug. One male and one female taken at Ft. Collins, June 5th, 1900.

mexicana Sauss. Occasionally introduced upon bunches of bananas from the south.

PERIPLANETA Burmeister.

americana Linn. A few examples from Ft. Collins and Denver.

orientalis Linn. One specimen taken at Golden, Colo., April 30th, 1902.

Family MANTIDÆ.

YERSINIA Saussure.

solitaria Scudd. Specimens of what seems to be this species have been taken at Ft. Collins, Palmer Lake, Durango and Alder. They have been taken in open places running about in short grass and so imitating the ground and dry leaves that they are never seen until they move. Rare.

LITANEUTRIA Saussure.

borealis Brun. Specimens of this species have been taken at Ft. Collins, Dutch George's, Holly and at Stratton and Kimball in Nebraska. Rare in Colorado.

minor Scudd. This species probably occurs quite generally over the plains region east of the foothills and a few miles into the hills, on dry grassy ground. Specimens have been taken at Ft. Collins, Dutch George's, Greeley, Pueblo and Trinidad.

obscura Scudd. A few specimens of what seems to be this species have been taken on the western slope at Grand Junction.

STAGMOMANTIS Saussure.

carolina Linn. A few specimens have been taken at Nepesta and at Grand Junction.

Family PHASMIDÆ.

DIAPHEROMERA Gray.

velliei Walsh. Taken at Holly, Sept. 8, '98, on corn, and at Julesburg Aug. 7, 1902 on grass on low ground. Rather common in both instances. (Ball.)

PARABACILLUS Caudell.

coloradus Scudd. A few specimens have been taken at Ft. Collins both inside and outside the foothills. In one instance two specimens were taken from a species of *Eriogonum*, July 27, '99. One of these was mature and one immature. We also have specimens from Kimball, Neb., taken Aug. 5th, 1899.

Family ACRIDIIDÆ.

TETTIX Charpentier.

acadicus Scudd. A single specimen taken at Steamboat Springs July 16, 1894. (Baker.)

crassus Morse. A common species in northeastern Colorado on low ground adjoining the foothills and near the streams in the canons. The adults hibernate during the winter among dead leaves. Most of the adults have been taken in the fall and early spring. This species varies much in color and in the length of the pronotum. Species taken at Ft. Collins, Laporte and Steamboat Springs only. Most of the specimens were taken in the foothills near Laporte.

hancocki Morse. Four specimens, all taken in Rist Canon near Laporte, June 15, 1898. (Ball.)

incurvatus Hanc. One specimen from Rist Canon, near Laporte, June 15, 1898, one ten miles farther back in the foothills July 21, 1898 (Ball.); and one specimen at Salt Lake, Utah, 6-16-'00. (Gillette.)

tentatus Morse. Two species taken at Little Beaver, 7-19-'98 at about 9,000 feet altitude, (Ball.); and two specimens taken in Estes Park, one July 11, and one July 15, '94, (Gillette). The last two named were rather immature. Altitude about 8,000 feet.

PARATETTIX Bolivar.

cucullatus Burm. A few specimens have been taken from the plains and foothills in the vicinity of Ft. Collins and a single specimen was taken at Lamar. The dates are in the months May and June.

tolticus Sauss. Four specimens, three taken in Rist Canon near Laporte, June 26, 1898, (Ball.); and one taken along the river near Ft. Collins 6-12-'97. (Gillette.)

MERMIRIA Stal.

bivittata Serv. Common over the entire eastern portion of the State to some distance within the foothills. This species seems to prefer the higher ground and is often abundant upon hill-tops. We have recorded specimens from Ft. Collins, Laporte, Windsor, Greeley, Orchard, Julesburg, Wray, Rockyford and Holly.

We have taken adults at Ft. Collins as early as July 10th and as late as Sept. 10th. They doubtless continue much later.

neomexicana Thom. This specimen seems to cover about the same ground as the preceding though it is much less abundant

We have specimens taken at Ft. Collins, both within and outside of the foothills, and also a few specimens taken at Rockyford, Holly and Nepesta. Our captures have all been made during August and September.

ACROLOPHITUS Thomas.

hirtipes Say. We have found this species most common in the gulches of the outer foothills and upon the dry hillsides. It probably occurs in small numbers over most of the plains of the eastern portion of the State. At Ft. Collins adults begin to appear about the last week in June. All our specimens have been taken before the last of August. Most of them are uniformly green in color but several individuals have a lighter shade, varing from light green to almost white upon the elytra and pronotum. Upon the elytra the lighter color is so distributed as to leave the green, for the most part, in round or oval blotches.

Specimens from Ft. Collins, Laporte, Livermore, Dutch George's, Wray, Greeley, Boulder, Golden, Las Animas and Coolidge, Ks. July 7, '02 all adult and eggs mature at Laporte. (Ball.)

ERITETTIX Bruner.

navicula Scudd. Specimens answering to the discription of this species seem not to be specifically distinct from *tricarinatus*. Perhaps Caudell is correct in thinking all the Colorado forms are *navicula*. See "note on Orthoptera, etc." by A. N. Caudell, Proc. U. S. National Museum, Vol. xxvi.

tricarinatus Thom. A common species on dry grass land in the eastern portion of the State and extending some distance into the foothills. Most common northward and near the foothills. Adults taken in northern Colorado from May 11th to August 13th.

Specimens have been taken at Ft. Collins, Laporte, Dutch George's, Virginia Dale, Livermore, Boulder, Palmer Lake, and Pueblo.

variabilis Brun. This species seems to be very generally distributed over the State up to an altitude of about 6,000 feet. We have taken it on grassy areas. It seems to feed mostly upon salt grasses. Adults were just beginning to appear at Ft. Collins June 22, 1899 (Ball) and we have taken them up to Sept. 23rd.

Specimens have been taken at Ft. Collins, Laporte, Windsor, Timnath, Greeley, Merino, Snyder, Julesburg, Boulder, Denver, Pueblo, Nepesta, Rockyford, Lamar, Holly and Delta.

AMPHITORNUS McNeill.

bicolor Thom. A very common species on dry grassy slopes over all the eastern portion of the State, particularly, northward near, and for some distance within the first foothills. Specimens have been taken at an altitude of fully 8,000 feet. This insect doubtless causes heavy losses on the native pasture lands of the State.

June 29, 1901, a single pair of adults and many young were found in the foothills west of Ft. Collins; June 6th, 1902, in the some locality only young nymphs could be found; at Greeley, June 23, 1902, several adults were seen. (Ball.) Our latest captures of this species at Ft. Collins were made Sept. 5, 1901.

Specimens have been taken at the following places: Ft. Collins, Laporte, Dutch George's, Livermore, Westlake, Windsor, Greeley, Merino, Wray, Julesburg, Snyder, Boulder, Denver, Rockyford, Las Animas, Holly, Lamar, Alder, Dunkley and Steamboat Springs.

CORDILLACRIS Rehn.

affinis Morse. A single male answering to the structural characters given for this species, but having the dark stripe of the hind femora solid, was taken by Mr. S. A. Johnson at Hayden, July 29th. The hind tibiæ are very pale yellowish tinged with dusky and not at all red.

cinerea Brun. What I have placed under this name seems to be a light colored form of *occipitalis*, and it occurs over about the same area. Perhaps my specimens are not true *cinerea*, but if so, we have not taken this species in the State.

crenulata Brun. Generally distributed on dry grassy areas east of the Continental Divide to 8,000 feet altitude and also occurring over some of the western slope. It seems to be a grass feeder. The earliest that adults have been seen at Ft. Collins is June 26, 1901. (Ball.) They continue until the middle of September.

Specimens taken at Ft.Collins, Laporte, Windsor, Greeley, LaSalle, Wray, Boulder, Denver, LaFayette, Colorado Springs, Pueblo, Rockyford, LaJunta, Lamar, Las Aninas, Trinidad, Ridgway, Antonito, Durango and Grand Junction.

occipitalis Thom. The notes for the preceding species may be repeated for this. In addition to the above localities we can add Dolores, Salida, Golden, Virginia Dale, Timnath, Ft. Morgan, Julesburg, Merino, Trinidad, Alamosa, Antonito and Durango.

Specimens from Trinidad, Alamosa, Antonito and Durango are darker in color and the elytra are longitudinally striped with dark fuscous with or without light yellow spots, but I do not take this form to be specifically distinct from the specimens from other parts of the State as there is considerable inter-gradation.

PHLIBOSTROMA Scudder.

quadrimaculatum Thom. A very common species feeding upon prairie grasses, particularly on the plains of the northeastern portion of Colorado. The species occurs in the foothills at an altitude of about 8,000 feet. It varies much in size and color, and in wing-length. This is one of our most destructive species to prairie grasses.

Specimens taken at Ft. Collins, Laporte, Dutch George's, Virginia Dale, Livermore, Windsor, Greeley, La Salle, Snyder, Sterling, Lafayette, Denver, Golden, Boulder, Pinewood, Pueblo, Colorado Springs, Rockyford, Holly and Buena Vista.

Adults taken at Ft. Collins from the 24th of June, 1901, until the 12th of October, 1898. Fully developed eggs found in females July 27th, 1901. (Ball.)

ORPHULELLA Giglio-Tos.

pelidna Burm. Thomas in writing of this species has said "Burmeister's description is so meager that it is doubtful whether it will ever be recognized with satisfactory certainty." What

I am calling this species is common in the northern plains portion of the State upon grassy areas and we have taken it in the foothills to an altitude of 5,500 feet. The males measure from 15 to 18 mm. and the females between 18 and 21 mm. in length. On going south this form gives way to a larger and longer winged form that I am calling *pratorum*. Scudd.

The specimens have been taken at Ft. Collins, Laporte, Windsor and Greeley. Adults have been taken as early as July 22, and as late as September 17th.

pratorum Scudd. What I am calling this species is abundant in the northern portion of the State east of the foothills and is also common in the southern portion. The males range between 18 and 20 mm. and the females between 21 and 24 mm. in length.

The specimens in the College collections have been taken at the following points: Ft. Collins, Greeley, Sterling, Snyder, Pueblo, Rockyford, Lamar and Holly in Colorado, and Stratton in Nebraska. See *Orphulella pelidna*.

salina Scudd. This low-ground species has been taken by us upon the west slope only in the vicinity of Delta and Grand Junction from July 7 to Sept. 23. On Sept. 17th, 1903, it was noted as the most abundant grasshopper on salt-grass, *Distichlis maratima*, growing through a heavy deposit of alkali on low ground near Delta. (Gillette.)

CHLŒALTIS Harris.

conspersa Harr. We have taken this species on five different dates at altitudes from 5,500 to 6,000 feet in the foothills west of Ft. Collins. The captures have all been from a single canon known as Horse-tooth Gulch and between July 10th and Aug. 12th. A single female was also taken in the foothills near Boulder July 23rd, 1901.

The females vary between 22 mm. and 24 mm. in length and their elytra vary between 8 mm. and 10 mm. in length. The males are from 18.5 mm. to 21 mm. in length and their elytra are from 9.5 mm. to 12.5 mm. long. In three of the males the entire sides of the pronotum to the lateral carinæ are black. In two others the lower portion is brown. The females lack the black dash upon the upper posterior angles of the sides of the pronotum. There are other reasons, particularly in the elytral venation of the males, for thinking that this Colorado form may be a new species.

STENOBOTHRUS Fischer.

curtipennis Harr. A common species on native grasses along the mountains and foothills of the State and occurring in smaller numbers across the plains of the northern portion. We have found it most abundant at altitudes of 8,000 to 9,000 feet. We have taken adults as early as June 26th in the foothills near Ft. Collins and as late as Sept. 30th in the same place. We have taken no females with elytra long enough to reach to the tip of the abdomen. With the males, however, the wings just attain the tip of the abdomen.

Specimens taken at Ft. Collins, Laporte, Dutch George's, Home, Sterling, Orchard, Merino, Greeley, Ward, Salida, Gunnison, Antonito, Lizzard Head, Alder, Cameron Pass and Walden.

PLATYBOTHRUS Scudder.

brunneus Thom. Both sexes taken in and near Estes Park, Aug. 11 to 13, 1903, sweeping native grasses between altitudes of 7,000 and 8,500 feet.

GOMPHOCERUS Thunberg.

clavatus Thom. This is preeminently a high-altitude species, though it occurs down to an altitude of something less than 5,000 feet, and has been taken by us along the Cache la Poudre river seven miles from the foothills. It occurs in large numbers on grassy areas above timberline. We have recorded it abundant on Mt. Ouray (near Marshall Pass) at 12,500 feet altitude, Aug. 27th, 1899.

In the foothills near Ft. Collins we have taken adults as early as June 17th, and on Marshall Pass as late as Oct. 7th. In the lower altitudes the species is not abundant.

We have taken specimens at Ft. Collins, Laporte, Dutch George's, Livermore, Westlake, Stove Prairie, Little Beaver, Home, Pueblo, Ward, Pike's Peak at 12,000 feet (Cockerell), Marshall Pass (on Mt. Ouray), and Cerro Summit.

The Colorado specimens are larger than Thomas' type, females measuring between 18 and 22 millimeters in length, with elytra 4.5 mm. to 8 mm. long, and males measuring between 15.5 mm. and 18 mm. in length.

It seems strange that the type of this species should have been recorded as taken in Kansas. Probably this is an error.

BOOPEDON Thomas.

nubilum Say. A rather common species along the Arkansas valley from Pueblo down, on moist ground where grasses grow. A few specimens have been taken from wheat and corn fields.

Outside of the Arkansas valley a specimen was taken at Wray (Ball). We have taken this species at Pueblo, Nepesta, Rockyford, Las Animas, Lamar and Wray.

All the males are black with hind tibiæ more or less red and with elytra nearly attaining the tip of the abdomen. In length they vary between 20 mm. and 27 mm. (52 specimens). Out of 30 females, 26 are dusky and greenish, marked with yellow, and four are black. They vary in length between 31 mm. and 44 mm., and, with one exception, the wings are short, about 12 mm. long. The single long-winged female has elytra surpassing the tip of the abdomen.

flavofasciatum Thos. Probably the light-colored form of the preceding species.

STIRAPLEURA Scudder.

decussata Scudd. Occurs across the plains and in the mountains to an altitude of 8,000 feet. Quite abundant in the vicinity of Ft. Collins. Occurs commonly in open grassy areas; food-plants not known.

Taken at Ft. Collins, Laporte, North Park, Denver, Colorado Springs, Pueblo, Rockyford, Lamar, Canon City, Trinidad, Antonito, Gunnison, Claremont, Elbert and Dunkley.

AGENOTETTIX McNeill.

deorum Scudd. What I take to be typical examples of this species in the collection are from Colorado Springs (Cockerell), Pueblo and Boulder, though others nearly as typical come from Rockyford, Ft. Collins and other points. This species seems to me to grade imperceptably into *scudderi*.

occidentalis Brun. (See discription following this article).

A west slope species, the specimens in the College collection coming from Antonito, Durango, Grand Junction, Glenwood Springs and Delta. Dates—Aug. 5th to Sept. 23rd.

scudderi Brun. A common species upon the plains near the foothills, particularly in the northern portion of the State. It extends to the eastern border of Colorado and to an altitude of 6,000 feet at least in the foothills. Adults begin to appear at Ft. Collins about June 20th and we have taken them as late as Sept. 28th. Adults were mating freely July 30th, 1902. (Ball.)

Specimens taken at Ft. Collins, Laporte, Dutch George's, Livermore, Greeley, Ft. Morgan, Snyder, Merino, Wray, Sterling, Julesburg, Boulder, Palmer Lake, Pueblo, Rockyford, Las Animas and Lamar. This species seems to me to be a unicolorous variety of *deorum*.

AULOCARA Scudder

elliotti Thom. This is also a very abundant species over the grass-covered plains of the eastern portion of the State, and occurs upon open grassy areas in the mountains to an altitude of 8000 feet. Adults appear in the vicinity of Ft. Collins about the middle of June and the sexes have been taken *in coitu* as early as July 2.

The 75 females in the collection vary in length between 21 mm. and 27 mm. and their elytra between 16 mm. and 18 mm. The males vary between 17 mm. and 20 mm. and their elytra between 11 mm. and 17 mm.

There is a wide variation in the colors. The common one is a dingy brown, slightly tinged with rufous, with more or less numerous brown spots, particularly upon the elytra. Occasional specimens are deep ferruginous in color with or without the fuscous spots upon the elytra and with the posterior portion of the dorsum of the pronotum deeply infuscated. Specimens from the higher altitudes (Buena Vista, Antonito and Gunnison) are smaller and are of a dark slate color with markings very inconspicuous.

Our specimens came from the following places: Ft. Collins, Laporte, Pike's Peak at 9000 feet (Cockerell), Dutch George's, Livermore, Sterling, Boulder, Lafayette, Va. Dale, Nepesta, Rockyford, Lamar, Trinidad, Canon City, Buena Vista, Antonito, Durango and Dunkley.

femoratum Scudd. A very abundant species near the foothills in northern Colorado. It occurs among the native grasses which probably serve as its food plants. It occurs entirely across the plains to the eastward but we have not found it occuring far back in the foothills nor upon the western slope. On July 16, 1902, adults were just beginning to appear in the foothills west of Fort Collins (Ball). In 1901 a few males were found in the same locality June 29, and on July 26th of this year Mr. Ball found females containing fully developed eggs. Occasional specimens have been observed at Fort Collins as late as Sept. 30, (1902).

This species has been collected at Ft. Collins, Laporte, Dutch George's, Windsor, Greeley, Ft. Morgan, Boulder, Rockyford, Las Animas, Lamar and Holly.

An examination of the 74 females and 52 males in the collection shows that the former vary between 19 and 25 mm. and their elytra between 12 mm. and 19 mm. in length, and that the latter vary between 14 mm. and 17 mm. and their elytra between

7 mm. and 12 mm. in length. The smaller size, shorter wing, conspicuous black bands upon the hind femora, and absence of the lower ridge for the inclosure of the frontal fovea easily separate this species from *elliotti*. In general appearance, the females of the two species are very similar.

rufum Scudd. We have found this species fairly common in the valleys of the Arkansas and the Rio Grande rivers and also at an altitude of about 8000 feet at Gunnison. We have also taken it upon the plains at Greeley and at LaSalle but not at Ft. Collins. The captures have been between June 24 (Greeley) and Aug. 11 (Denver).

Taken at Greeley, LaSalle, Denver, Pueblo, Nepesta, Rockyford, Lamar, Antonito and Gunnison.

This species also varies greatly in color. There are colors from light to dark slate through various shades of ferruginous. In some the elytra are conspicuously spotted with brown while in others the maculation is almost entirely absent. The posterior margin of the dorsum of the pronotum is usually darkened so as to be in sharp contrast to the lighter color of the elytra.

ARPHIA Stal.

frigida Scudd. We have taken this species at altitudes ranging between 5500 feet in Rist Canon near Ft. Collins and 12,000 feet on Marshall Pass.

This yellow-winged species has also been taken at Westlake, Little Beaver, North Park, Glendevy and Home. It seems to be distinctly a mountain species. We have not taken it outside of the foothills.

***pseudonietana** Thom. This large species with bright red under wings heavily bordered with black is quite abundant in northern Colorado and especially along the eastern foothills in the most barren places. It so imitates the ground upon which it rests that it can hardly be seen until it moves. It occurs to the New Mexico line in the southern part of the State. Our specimens come from the following points: Ft. Collins, Laporte, Dutch George's, Livermore, Sterling, Home, Windsor, Greeley, Orchard, Merino, Pinewood, Denver, Boulder, Palmer Lake, Colorado Springs, Pueblo, Rockyford, Las Animas, and Lamar.

The earliest capture was at Lamar, May 7, 1892, and the latest at Palmer Lake, Oct. 9th, 1898.

*I am following A. N. Caudell in calling this species *pseudonietana* Thomas, instead of *tenebrosa* Scudder.

tenerata Scudd. This species, which may be only a red-winged variety of *frigida*, is very common upon the plains in the vicinity of the foothills in northern Colorado. Our dates of capture range between March 31 and July 12 (Ft. Collins).

Our specimens have been taken at the following points within the State: Ft. Collins, Laporte, Greeley, Pueblo, and a single specimen from Silverton which may be a different species. We also have a pair of what seem identical with this form from Dunkley.

CHORTOPHAGA Saussure.

viridifasciata DeGeer. A common species in northern Colorado in the vicinity of Ft. Collins and occuring a short distance in the foothills. Adults have been taken as early as Apr. 23, and as late as July 2. The species winters as a nymph. The males (17) in the college collection are all brown. Out of the 25 females, 11 have the sides of the elytra and pronotum decidedly brown. Our specimens all came from the plains and foothills near Ft. Collins.

ENCOPTOLOPHUS Scudder.

coloradensis Bruner. See description in article following this.

costalis Scudd. Not uncommon near the foothills in the vicinity of Ft. Collins, also occuring some distance within the hills. Our specimens came mostly from near Ft. Collins, a few are from Greeley and one from Antonito.

CAMNULA Stal.

pellucida Scudd. A common species in open areas throughout the mountainous portions of the State. We have not taken it east of the foothills. More than 100 specimens in the College collection were taken at the following points: Home, North Park, Va. Dale, Dutch George's, Little Beaver, Pike's Peak at 10,000 ft. (Cockerell), Walden, Westlake, Sterling, Livermore, Stove Prairie, Cameron Pass, Leadville, Marshall Pass, Salida, Ward, Estes Park, Gunnison, Grand Junction, Rico, Hamilton, Steamboat Springs, Dolores, and Glenwood Springs. From outside the State, we have taken this species at Cheyenne, Wyo., and at Chama, N. M.

HIPPISCUS Saussure.

conspicuus Scudd. A fairly common species over the plains of the eastern portion of the State and in the lower altitudes through the mountains of the southern portion. Specimens in the collection are from Ft. Collins, Snyder, Sterling, Lamar, Pueblo, Trinidad, Antonito, and Gunnison.

The dates of capture range between May 9th and August 28 at Ft. Collins.

montanus Thom. Specimens determined for us by Prof. Bruner as this species were taken by Prof. E. D. Ball at Lamar, Colo., on three different dates, June 17, July 10, and July 18; and at Wray, Colo., July 13. It is one of the very largest and is the lightest colored species we have taken. The largest females measure 48 mm. in length. The hind femora and tibiæ beneath and on the inner sides are bright coral red and the metazone of the pronotum is long and acute angled posteriorly.

neglectus Thom. This seems to be strictly a mountain species. A single specimen has been taken on the first line of foothills west of Fort Collins at an altitude of about 5,500 feet, and at about 6,500 feet it becomes fairly common. Over 80 specimens in the College collection came from the following points: Ft. Collins (foothills), Livermore, Va. Dale, Westlake, Dutch George's, Estes Park, Home, North Park, Pike's Peak, Alder, Gunnison, Dolores, Steamboat Springs and Walden. Dates range between June 16 and Aug. 29.

paradoxus Thom, One male from Antonito, Aug. 5, '00 (Ball,) is all we have taken of this species. Determined by Prof. Bruner.

variegatus Scudd. Two males and two females taken by Prof. E. D. Ball at Holly, Colo., Sept. 8, 1898.

zapotecus Sauss. A few specimens of this species have been taken from the following points: Ft. Collins (foothills), Livermore, Westlake, Palmer Lake, Steamboat Springs, Eddy and Dunkley.

LEPRUS. Saussure.

cyaneus Ckll. Occuring in the most barren situations across the southern portion of the State. Our specimens came from Nepesta, Pueblo, Trinidad, Delta and Grand Junction. Determined by Prof. Cockerell. The hind wings of all the specimens are deep blue bordered with black and correspond exactly to Cockerell's description (Ent. News, 1902, p. 305.) The closely allied species, *wheeleri*, we have not taken in the State.

DISSOSTEIRA Scudder.

carolina Linn. Generally distributed over the State up to an altitude of about 8,000 feet. Adults taken from July 8th (Palisades) to Sep. 25 (Pueblo). Locations of capture: Ft. Collins, Laporte, Va. Dale, Dutch George's, Greeley, Orchard, Boulder, Pueblo, LaJunta, Lamar, Holly, Alamosa, Durango, Mc-

Elmo, Antonito, Cortez, Grand Junction, Delta, Hotchkiss, Paonia, Glenwood Springs, and Estes Park.

longipennis Thom. A common species east of the foothills, particularly in the southern portion of the State where it extends west into the foothills. It is very rarely that a specimen is seen at Ft. Collins. It is a common insect at the electric lights in Denver and at Colo. Springs. The college specimens are from Fort Collins, Greeley, Snyder, Sterling, Ft. Morgan, Denver, Pueblo, Canon City, Rockyford, Las Animas, LaJunta, Lamar, and Holly.

SPHARAGEMON Scudd.

aequale Say. A fairly common species in eastern Colorado and extending a short distance into the foothills. Our specimens come from Ft. Collins, Ft. Morgan, Boulder, Colorado Springs, Rockyford and LaJunta. The dates of capture are from July 8th to Sep. 14th. Large females have a striking resemblance to *Hadrotettix trifasciatus*.

collare Scudd. Our specimens, few in number, have been taken at Ft. Collins, Greeley, Orchard and Pueblo. A few of the Ft. Collins specimens were taken a mile or two back in the foothills. The dates range between July 10th and Oct. 3d.

cristatum Scudd. We have but few captures of this species, coming mostly from the eastern and southern portions of the State. The localities are Ft. Collins, Wray, Pueblo, Rockyford, Lamar, and from Stratton in Nebraska.

humile Morse. This is one of the most common species in the northern and eastern portions of the State. According to our collections it extends into the mountains to an altitude of about 9,000 feet. The captures are from the following points: Ft. Collins (both plains and foothills), Livermore, Dutch George's, Sterling, Ft. Morgan, Snyder, Wray, Orchard, Denver, Pinewood and Buena Vista. The dates of capture range between July 8th (Ft. Collins) and Sep. 19th (Buena Vista). The specimens that I am referring to this species seem hardly to be specifically distinct from *aequale*.

pallidum Morse. Along with the typical light colored specimens belonging to this species as determined for me by Prof. Bruner and Prof. Morse I have included a number of darker color that seem in every other way to be identical. The specimens before me came from the following points: Ft. Collins, Laporte, Greeley, Julesburg, Orchard, Denver, Pueblo, LaJunta, Lamar, Rifle and Delta.

DEROTMEMA Scudder.

haydeni Thos. This is a very common species throughout the State up to an altitude of about 9,000 feet, Light colored specimens that seem to be the true *cupidineum* of Scudder seem to me to grade insensibly into true *haydeni*, so I am including all under this name. Mr. Caudell distinguished *cupidineum* by the narrower black band of the wings which does not seem to hold true in all the spread specimens I have examined.

The 100 and more specimens of the College collection come from the following localities: Ft. Collins, Laporte, Livermore, Dutch George's, Julesburg, Ft. Morgan, Orchard, Sterling, Greeley, LaSalle, Lafayette, Denver, Boulder, Palmer Lake, Colorado Springs, Glenwood Springs, Pueblo, Rockyford, Las Animas, LaJunta, Lamar, Trinidad, Canon City, Salida, Buena Vista, Rifle, Colorado Springs, Gunnison, Antonito, Durango, Dolores, Delta and Grand Junction.

MESTOBREGMA Scudder.

thomasi Caud. (*cinctum* Thos.) Eight specimens collected from the following points: Colo. Springs, Pueblo and Nepesta. Dates range from July 19th to Sep. 25th.

kiowa Thom. A very common species on native grasses over the State generally, occuring in the mountains up to an altitude of fully 10,000 feet. Caudell reports having taken this species on the summit of Pike's Peak. The College collection of over 200 specimens came from Ft. Collins, Livermore, Dutch George's, Va. Dale, Julesburg, Sterling, Merino, Wray, Greeley, Windsor, Boulder, Denver, Colo. Springs, Pueblo, Palmer Lake, Rockyford, Las Animas, Trinidad, Ridgway, Antonito, Durango, Gunnison, Alma, Rifle, Estes Park, Steamboat Springs, Dunkley, Hamilton and Hayden. Dates of capture July 2nd to Oct. 9th.

mexicanum Sauss. Our 30 specimens of this robust species came from Ft. Collins, Dutch George's, Palmer Lake, Pueblo and Trinidad. Dates, Aug. 13th to Oct. 9th.

plattei Thom. A rather common species over the plains of the eastern portion of the State and occuring in the lower regions of the eastern slope to an altitude of 8,000 feet. The College specimens are from Ft. Collins, Dutch George's, Sterling, Wray, Home, Pinewood, Boulder, Colo. Springs, Pueblo, Rockyford, Nepesta, Las Animas, Lamar, Trinidad and Antonito. The dates range between July 8th and Sep. 3.

pulchella Bruner. (Determined by Prof. Bruner). Our 30 specimens of this beautiful green and black species are in the collection

from Ft. Collins and Va. Dale and one from Kimball, Neb. Dates, July 17 to August 16.

METATOR.

pardalinus Sauss. This is a common species in the vicinity of Ft. Collins. The College specimens are from Ft. Collins, Va. Dale, Dutch George's, Sterling, Steamboat Springs and Boulder. Dates range between June 28th and Sep. 12th.

There are 14 females and 6 males with red wings, and 14 females and 16 males with yellow wings.

CONOZOA Saussure.

gracilis Thos. The 55 specimens of this speeies in the College collection are all from the mountains except a specimen from Greeley and one from Pueblo. The localities of the captures are Greeley, North Park, Pueblo, Alder, Alamosa, Durango, Cortez, Dolores, Gunnison, Rifle, Paonia, Grand Junction, Steamboat Springs, Walden, Maybell, Hamilton, Glendevy, Lay, Dunkley and Craig.

TRIMEROTROPIS Stal.

azurescens Brun. A few specimens of this blue-winged species have been taken at Rifle, Paonia, Delta, Steamboat Springs and Hamilton, on the most barren hill-sides. July 25th to Sep. 23d.

agrestis McNeill. Specimens of this species as determined for me by Prof. Bruner come from Julesburg, Orchard, Greeley, Rockyford, LaJunta and Lamar.

bruneri McNeill. This is a common species on the northern plains of the State. In general appearance and markings it is wonderfully like *Hadrotettix trifasciatus*. The females are about the size of the males of that species. Specimens in the College collection are from Ft. Collins, Greeley, Ft. Morgan, Sterling, Pueblo, LaJunta and Antonito.

cincta Thom. There are 36 females and 59 males of this species in the collection and all came from the mountains or foothills of the State. Without exception the hind tibiæ are bluish or yellowish with a dusky patch a little beneath the knees in just the position to meet the black spot in the sulcus of the under surface of the femur. There are several specimens marked Ft. Collins in the collection but all came from Horse-Tooth mountain, a high foothill about 8 miles south-west of town. Our specimens have been taken at altitudes ranging between 6,000 and 10,000 feet and from both slopes.

citrina Scudd. A common and one of the very largest species that we have taken. I am including under this name forms that

seem to go well under *laticincta* and *latifasciata* but for which I am unable to find specific characters different from what I am calling *citrini*. Our specimens have been taken at the following places: Ft. Collins, Greeley, Va. Dale, Dutch George's, Ft. Morgan, Livermore, Pueblo, Rockyford, LaJunta, Lamar, Dolores and Durango. June 16 (Rockyford) to Oct. 6 (Ft. Collins.)

inconspicua Bruner. (See description in article following this).

monticola Sauss. A common species along the eastern foothills and extending across the plains in the northern portion of the State. It also occurs in the mountains of the central portion of the State to an altitude of 9,000 feet. Specimens taken at Ft. Collins, Livermore, Dutch George's, Va. Dale, Estes Park, North Park, Greeley, LaSalle, Colo. Springs, Ft. Morgan, Palmer Lake, Trinidad, Alder, Canon City, Buena Vista, and from Tie-Siding in Wyoming. Dates of capture, June 18 (Palmer Lake) to Sep. 18 (Palmer Lake).

montana McNeill. Five specimens of this species came from Durango, Grand Junction and Delta. July 28th to Sep. 23d. (Determined by Prof. Bruner and by Prof. Morse).

obscura Scudd. A few examples of this species all from mountainous districts: Palmer Lake, Salida, Antonito, Silverton (12,000 ft.), Pike's Peak at 11,000 ft. (Cockerell), Steamboat Springs, Pagoda, Hamilton, Hebron and Lay.

vinculata Scudd. A common species across the southern portion of the State and occuring as far north, at least, as Ft. Collins. The localities of our captures are: Ft. Collins, Greeley, Pueblo, Colo. Springs, LaJunta, Nepesta, Lamar, Durango, Cortez, Dolores, Antonito, Alamosa, Palisades, Delta, Steamboat Springs, Craig, Maybell and Hamilton. Dates of capture are between June 15th (Pueblo) and Oct. 8th (Salida).

In this lot are a few specimens that I kept separate for a time as *similis*, but as the number of specimens increased the two forms seemed to run together. (Since writing the above the examples supposed to be *similis* have been determined for me by Prof. Morse as a form of *vinculata*).

CIRCOTETTIX Scudder.

carlinianus Thom. The specimens in the College collection are mostly from the vicinity of Ft. Collins. Other localities of capture are: Livermore, North Park, Dunkley, Palmer Lake, Colo. Springs, Durango, Grand Junction and Gunnison. Dates, June 26th to Oct. 4th at Ft. Collins.

suffusus Scudd. This very dark slender species we have taken in the foothills only, chiefly of the western slope, and in altitudes ranging between 7,000 and 8,000 feet. The males are very noisy with their wings. Rather common. Points of capture: Walden, Steamboat Springs, Dunkley, Estes Park, Palmer Lake, Durango, Hamilton and Pagoda.

undulatus Thom. Our examples of this species are from Ft. Collins, Dutch George's, Wray, Pueblo, Hague's Peak, Manitou, and Rifle; July 13th to Sep. 10th.

verruculatus Kirb. A mountain species which we have found more common in the middle and southern portions of the State. Our specimens are from Ft. Collins (foothills), Estes Park, Golden, Ward, Palmer Lake, Salida, Marshall Pass, Pike's Peak, Buena Vista, Paonia, Delta, Durango, Dolores, Rico, Steamboat Springs, Pagoda, Dunkley and Hamilton. Dates of capture, July 13th (Palmer Lake) to Oct. 8th (Salida).

HADROTETTIX Scudder.

trifasciatus Say. A common species over the native grass lands of the eastern portion of the State and extending some distance within the foothills. Some of the College specimens came from fully 8,000 feet altitude. Localities: Ft. Collins, Dutch George's, Livermore, Pinewood, Greeley, Wray, LaSalle, Sterling, Golden, Pueblo, Canon City, Rockyford, LaJunta, Lamar, Holly, Antonito and Salida. Dates, July 10th to Oct. 10th (Ft. Collins).

PARAPOMALA Scudder.

cylindrica Brun. This species probably occurs over the greater portion of the eastern plains of the State and in the lower foothills, where blue-grass, *Agropyrum glaucum* grows, which seems to be the chief food-plant. Localities of capture: Ft. Collins, (plains and foot-hills), Windsor, Orchard, Snyder, Julesburg, LaSalle, Rockyford, Las Animas and Lamar. Adults June 16th to Sep. 14th at Rockyford. We also have specimens from Stratton, Neb. (Ball).

Both green and brown forms occur throughout the range. I see no way to distinguish this species from *wyomingensis* Thos.

BRACHYSTOLA Scudder.

magna Gir. This very large species, commonly known as the "lubber" is quite common over the eastern plains to the foothills. It also occurs some little distance inside the hills in open grassy areas. We have noted it feeding upon American laurel, *Kalmia glauca*, and upon groundsel, *Senecio* sp. (Ball). The

males in the collection measure between 43 mm. and 61 mm., and the females between 45 mm. and 61 mm. in length.

The earliest we have found adults at Ft. Collins was July 10, 1901, and then only a single specimen could be found. On the 22d of the month adults were common and mating had begun. On Aug 1st of the same year some had begun to lay eggs and on Sep. 5th adults were common and several pairs were seen *in coitu* (Ball). Egg-laying begins about Aug. 1st.

In the males of this species the short wings are approximate or even overlapping on the back while in the females they are always widely separated.

SCHISTOCERCA Stal.

albolineata Thomas. What I am considering as this species are very closely related to the preceding, the only striking difference being the coral red hind tibiæ. There are specimens from Ft. Collins, Windsor, Timnath, Greeley, Merino, Orchard, Sterling, Julesburg, Nepesta, Rockyford, Lamar, Holly, Glenwood Springs, Grand Junction, Delta and Durango in the collection. The examples from the last four places named lack the black spots on the hind margins of the abdominal segments and have the hind tibiæ lighter red in color. The elytra are not noticably darker bordering the yellow stripe and the notch in the subgenital plate of the male is U-shaped, being broader than deep. Specimens from Delta and Grand Junction were taken from willows and from apple and peach trees. When disturbed they would take wing and fly from tree to tree. It is very likely these belong to a different species than the specimens from the eastern slope.

lineata Thom. This species occurs entirely across the State from north to south, east of the mountains. It occurs along water courses and seems to be arboreal in habit.

The males vary between 30 mm. and 35 mm. in length to tip of abdomen, and between 36 mm. and 43 mm. to tips of elytra. The females vary between 35 mm. and 48 mm. to tip of abdomen and between 42 mm. and 57 mm. to the tips of the wings.

The species varies very much in coloration; some are very pale yellow, others are yellowish green, and still others are of a rusty yellow. All have the hind tibiæ black behind and yellow before.

The earliest we have taken adults at Ft. Collins was July 10, 1899. Specimens have been taken as late as Sep. 5th at the same place and as late as Sep. 14, 1898 at Rockyford.

Specimens have been taken at Ft. Collins, Windsor, Greeley, Merino, Julesburg, Orchard, Manitou, Nepesta, Rockyford, Lamar, Holly and Trinidad.

HYPOCHLORA Brunner.

alba Dodge. This is a common species over the plains region of Colorado where its food plants occur. The two species upon which it chiefly occurs are *Artemisia frigida* and *A. ludoviciana* (white sage). It is not readily seen among the leaves of these plants which it closely imitates in color. The colors vary from a pale yellowish green to a rusty brown.

A large number of specimens in the College collection vary between 15 mm. and 19 mm. in length in the males, and between 21 mm. and 25 mm. in length in the females. The short pointed elytra measure between 4 mm. and 5 mm. in length in the males and between 5 mm. and 6½ mm. in the females. So far as known this insect attacks no cultivated plant.

Adults have been taken as early as July 8, 1898, at Ft. Collins and as late as Oct. 14th, 1901, at the same place. It has also been taken at Denver, Boulder and Julesburg, Colorado, and at Kimball, Nebraska.

CAMPYLACANTHA Scudder.

olivacea Scudd., seems to occur in the south-eastern portion of the State only. Several specimens were taken Sep. 8, 1898, at Holly, and others at Trinidad four days later, all by E. D. Ball.

This grasshopper is said to be partial to sunflower (*Helianthus*), and to lamb's quarter (*Chenopodium*), and Bruner suspects it of feeding upon beets also.

The 21 males in the College collection vary between 18 mm. and 22 mm. in length and the tegmina vary between 5 mm. and 7 mm. The 28 females vary between 22 mm. and 29 mm. in length and the tegmina vary between 5 mm. and 8 mm.

HESPEROTETTIX Scudder.

coloradensis Brun. (See description in article following this).

gillettei Brun. (See description in article following this). This seems to be a rare species in Colorado. After considerable searching I took five specimens from *Gutierrezia euthamiæ* at Glenwood Springs Sep. 15th, 1903. The collection also contains specimens from Delta, Grand Junction and Rifle, all points upon the west slope. July 13th to Sep. 16th.

pratensis Scudd. This is a fairly common, though not an abundant species over the plains and lower foothills of eastern Colorado. It seems to be of no economic importance as we have only recorded it feeding upon sunflower (*Helianthus*).

Our earliest were taken at Ft. Collins, July 6th, 1901, and our latest were taken at Greeley, Oct. 3, 1902. At Rockyford, July 16, 1901, this species was just becoming adult upon sunflowers. (Ball). At Ft. Collins on June 26 of the same year the nymphs were noted as being one-third grown (Ball).

We have made captures of this insect at the following points in the State: Ft. Collins, Livermore, Dutch George's, Home, Julesburg, Merino, Wray, Bald*Mt., Boulder, Golden, Palmer Lake, Colorado Springs, Lamar and Holly; also at Kimball and Stratton, Nebraska (Ball).

The greatest altitude at which we have taken this species is between 7,000 and 8,000 feet.

speciosus Scudd. This species occupies the same regions, practically as *pratensis*. It extends over the entire eastern portion of the State to the foothills and we have taken specimens at an elevation of somewhat over 6,000 feet in the hills.

The native food-plants of this species are sunflower (*Helianthus*) and a closely related composite, *Iva xanthifolia*. It is a much more abundant grasshopper than *pratensis*.

This species has been taken at the following places: Ft. Collins, Livermore, Dutch George's, Sterling, Julesburg, Orchard, Wray, Greeley, Merino, Pueblo, Rockyford, Las Animas, Nepesta, Lamar and Holly.

The 34 males in the collection vary between 20 mm. and 26 mm. in length, and the 66 females vary between 25 mm. and 34 mm. The wings are variable in length but in the great majority of cases they fall a little short of the tip of the abdomen in both sexes. Sometimes they are considerably shorter than the abdomen and occasionally they are slighlty longer. The males above mentioned have wings varying between 20 mm. and 26 mm. and the females have wings between 13 mm. and 24 mm. in length.

As this grasshopper feeds entirely upon native weeds it can not be considered of economic importance.

viridis Thom. This is one of the handsomest and most common of the plains species and occurs over all the eastern portion of the State up to the base of the foothills, where it is as abun-

*West of Loveland on Estes Park road.

dant as anywhere. It extends into the foothills for ten or fifteen miles in places and occurs as high as 7,000 feet in altitude, at least.

The native food plants are *Bigelovia* (rayless goldenrod) and *Gutierrezia euthamiæ*.

We have records of this species in the following places within the State: Ft. Collins, Dutch George's, Windsor, Greeley, Sterling, Wray, Boulder, Denver, Colo. Springs, Pueblo, Rockyford, Las Animas, Lamar, Nepesta and Holly.

Adults have been taken as early as July 2, 1901, at Ft. Collins and they were still abundant and mating freely at the foothills west of the town as late as Oct. 8, 1902 (Ball).

This species has not acquired, an appetite for cultivated plants and its native food-plants are not of economic value.

PODISMA Latreille.

dodgei Thom. This is distinctly a mountain species. We have taken it from just inside the first foothills at an altitude of 5,500 feet to 12,000 feet altitude upon the mountains. From 8,000 to 10,000 feet it is a rather abundant species. Food-plants unknown.

We have taken this species at the following Colorado points: Ft. Collins (foothills), Livermore, Dutch George's, Home, Ward, North Park, Lizard Head, Pike's Peak 12,000 feet (Cockerell) and Rico, as well as at several intermediate mountain points.

We have taken adults as early as June 12, 1900, near Ft. Collins and as late as Sep. 28th, 1898 in the same locality.

The 75 males in the collection vary between 14 mm. and 19 mm. in length and the 95 females between 21 mm. and 32 mm. The wings of the males vary between 4.5 mm. and 6.5 mm. and those of the females vary between 6 mm. and 8.5 mm.

stupefacta Scudd. Seventy-three males and 80 females of this species were taken by Mr. Charles Jones above timberline near Silverton, Colo., during August, 1903. He found this by far the most abundant grasshopper above 12,000 feet altitude in that vicinity. The hind tibiæ are universally red.

AEOLOPLUS Scudder.

chenopodii Brun. Taken at Grand Junction July 7, 1901, July 29, 1901, and Aug. 29, 1899; Palisades July 8, 1901, and Delta Sept. 23, 1901. The food-plant is a common species of *Atriplex* that is native upon the unirrigated ground in the neigh-

borhoods where the grasshoppers were taken. This species has been found fairly common about its food-plant. Upon being disturbed the hoppers jump in among the bunches of weeds and fall to the ground where they remain motionless for a time and are found with some difficulty as their color blends readily either with the food-plant or the ground.

The males vary between 14 mm. and 16 mm. and the females between 16 mm. and 22 mm. in length. The short elytra of the males vary little from 2 ½ mm. and those of the females vary little from 3 ½ mm. in length. Twenty-five males and 32 females examined.

minor Brun. (See description following this article).

plagosus Scudd. A few specimens of this species were taken at Delta, Colo., July 13, '01. They were fairly common on *Sarcobatus* sp. (greasewood), which was growing abundantly on seepage ground about the town. (Gillette.)

turnbulli Brun. This is a common Species over the plains region of Colorado east of the foothills. Its chief food-plants are species of *Atriplex* and Russian thistle. It has been seen feeding upon *Cleome* where its common food-plants were very scarce. *Atriplex expansa*, *A. canescens* and white sage, *Eurotia lanata*, have been specially noted as food plants of this insect.

We have taken this species at the following points in Colorado: Ft. Collins, Livermore, Julesburg, Sterling, Greeley, Ft. Morgan, Pueblo, Nepesta, Rockyford, Las Animas and Salida. The last named point is the only one any distance within the foothills where we have taken this species and only occasional specimens could be found there.

The Colorado specimens range rather larger in size than the types described by Prof. Bruner. The large number of specimens in the College collection measure as follows: Males between 17 mm. and 20 mm.; females between 17 mm. and 25 mm. The elytra vary somewhat in length but in nearly all cases they exceed the tip of the abdomen in both sexes. We have taken several females with short elytra, about 7 mm. in length, but have taken no short-winged males.

Adults have been taken from June 16 (Rockyford) to October 8 (Ft. Collins). The earliest that adults have been taken at Ft. Collins is June 26.

At the latest date mentioned, Oct. 8, many of the females still had immature ova of the second crop. (Ball.) Fourteen females were dissected Aug. 19th and only three seemed to have deposited their first batch of eggs. (Ball.)

This species, feeding almost exclusively upon weeds, can not be considered injurious at present and is not likely to become so unless it turns its attention to sugar beets which are closely related to the weeds upon which the hopper feeds.

MELANOPLUS Stal.

alpinus Brun. Taken between North Park and Cameron Pass, Aug. 20, 1899. (Ball.)

angustipennis Dodge. A single male answering the description of this species has been taken at Colorado Springs, Colo. It is indistinguishable from numerous specimens of *M. coccineipes* except for the blue hind tibiæ. It seems probable that *coccineipes* is a red-legged var. of *angustipennis*.

atlanis Riley. This is undoubtedly the most generally distributed species of locust in Colorado. It may almost be said to occur everywhere up to an altitude of 8,500 feet. Adults may be seen from about the 20th of June until after there have been several heavy frosts in the fall. This species is extremely variable in size and coloration. The lighter colored individuals have head, body and legs, except hind tibiæ, pale yellowish to rusty brown in color and even the elytra may partake of the color to a considerable extent. The latter may be conspicuously flecked with dusky spots or the dark spots may be entirely wanting. The light colored specimens are more prevalent in the lower warmer areas and early in the season and it is in the lower altitudes that the species attains its largest size. Specimens taken at 7,000 feet altitude and higher are nearly all small, dark-colored and without distinct markings. A common range in size between the small dark males of high altitudes and the larger ones of the eastern portion of the State is from 16.5 mm. to 26 mm., and the females range between 22 mm. and 27 mm. This insect does its injuries very largely to the native pastures though it is not averse to feeding upon various cultivated crops. It is certainly one of the most destructive grasshoppers to the native range pastures of the State.

At Ft. Collins, adults have been taken from June 22nd to November 11th. Many of the females taken on the latter date, 1902, still contained their second pod of eggs undeposited (Gillette). On July 26, 1901, a number of females were dissected at Ft. Collins and none of them had the first pod of eggs sufficiently matured for deposition (Ball). This species is evidently single brooded.

We have taken this species at the following points within the State: Ft. Collins, Laporte, Dutch George's, Liver-

more, Stove Prairie, North Park, Pike's Peak at 1,000 feet (Cockerell), Windsor, Greeley, Merino, Wray, Ft. Morgan Julesburg, Boulder, Lafayette, Denver, Palmer Lake, Canon City, Nepesta, Rockyford, Lamar, Holly, Trinidad, Colorado Springs, Salida, Buena Vista, Gunnison, Delta, Paonia, Grand Junction, Palisades, Durango and Steamboat Springs.

It seems probable that some of the reported occurrences of *Melanoplus spretus* should have been referred to this species.

bivittatus Say. This is undoubtedly the most injurious grasshopper in Colorado. It is doubtful if any insect causes heavier annual loss to the State. It is nearly, and perhaps quite as widely distributed as *femur-rubrum*. Its large size and great numbers and its appetite for cultivated plants of nearly every kind, make it very destructive. It is especially numerous in the alfalfa fields of the irrigated region near the foothills. Towards the eastern border of the State it is often out numbered by *differentialis*. It is also abundant in the alfalfa and grain fields of the western slope and sometimes defoliates fruit trees when orchards are not kept cultivated or when they are alongside of alfalfa or pasture land.

This species is capable of subsisting upon almost any cultivated crop. We have noted the following food plants: Alfalfa, red clover, grass, corn, wheat, oats, barley, fruit trees in general, cabbages, beets, potatoes and onions.

It has a strong tendency to climb tall plants and fence posts to rest for the night. The injuries are usually worst about the borders of fields.

There is comparatively little variation in the coloration of this species. The two yellow lines upon the elytra seem always to be present as a distinguishing characteristic; the head and pronotum are occasionally almost entirely pale yellow in color: In size and in wing-length this species varies widely. Males of long winged specimens vary between 21 mm. and 33 mm. in length and the females between 27 mm. and 41 mm. The majority of the specimens have elytra exceeding the tip of the abdomen but individuals with abbreviated wings are common and it is not very infrequent that they do not cover more that two-thirds of the abdomen. There are small males in the collection with elytra only 7.5 mm. long. As in *femur-rubrum*, the short winged individuals average smaller than those having long wings.

The earliest we have taken adults at Ft. Collins was June 12, 1900. June 21, 1901, a single male was found, and on

the 26th of the same month adult males were quite common (Ball). There is but one brood, as with all our Melanopli, but many of the eggs hatch late so that small nymphs are seen after many are adults. November 11, 1902, numerous females were seen at Ft. Collins and some of these had ova that were still immature (Gillette). Sept. 2, 1902, at Ft. Collins, occasional nymphs were seen and dissection of adult females showed that only about half of them had deposited the first pod of eggs. (Ball.)

We have recorded the species from the following places: Ft. Collins, Laporte, Livermore, Steamboat Springs, Eddy, Greeley, Sterling, Merino, Julesburg, Denver, Golden, Colorado Springs, Pueblo, Canon City, LaJunta, Rockyford, Lamar, Salida, Alder, Antonito, Delta, Grand Junction and Palmer Lake.

All the specimens in the collection have blue hind tibiæ and I do not remember certainly to have seen the form (or species) with red hind tibiæ in Colorado. It seems to me I have, but if so, the red-legged ones are only of occasional occurrence.

bowditchi Scudd. A common species in the southern portion of Colorado east of the foothills, and occurring in small numbers in the northern portion also. In the north it is largely replaced by a closely allied species *M. flavidus*. It is distinctively a plains species, and, so far as is known, confines its injuries to the native plants. We have found this species specially abundant along the Arkansas valley. Our dates of capture range between June 17th, 1900, at Lamar and Sept. 10th, 1898, in the same place (Ball). Food-plants unknown.

The males vary between 22 mm. and 25 mm. and the large females measure 30 mm. This species is readily separated from *flavidus* by its shorter antennæ (only 11 mm. long in the males) and by the presence of the black post-ocular band. It is also smaller and less robust as taken in Colorado. The fucula vary much in form at their tips. They may be truncate, cut diagonally, rounded, or slightly hooked, and two of these forms may occur on the same grasshopper.

Taken at the following places: Ft. Collins, LaSalle, Greeley, Timnath, Rockyford, Lamar and Colorado Springs, also at Kimball and Stratton in Nebraska. (Ball.)

coccineipes Scudd. This species occurs in moderate numbers over the entire plains region of Colorado and extends for some distance into the foothills. It varies in color from a dark

fuscous brown to almost a uniform and rather light rust-yellow. The lighter colored specimens occur mostly in the southern portion of the State. The post-ocular stripe varies from a broad and distinct black band to none. The subgenital plate is usually notched but in some specimens it is truncate. It seems quite probable to me that this species is nothing more than a form of *angustipennis* having red hind tibiæ.

The males we have taken vary between 19 mm. and 24 mm. in length. The females resemble allied species so closely that it is difficult or even impossible to distinguish them.

The only native food-plant we have recorded for this species is *Artemisia filifolia*. We have also taken it common on alfalfa and on young apple and plum trees.

Specimens have been taken at the following places: Ft. Collins (common), Laporte, Livermore, Dutch George's, Timnath, Greeley, Orchard, Julesburg, LaSalle, Boulder, Pueblo, Colorado Springs, Canon City, Lamar and Holly. Adult males and females have been taken at Ft. Collins as early as July 10, 1901, and as late as October 12, 1898.

comptus Scudd. We have a half dozen specimens of what seem to be *M. coccineipes* except that the furcula are nearly straight and but little diverging. So, while I should consider these as varieties of *coccineipes* I list them here because they seem to correspond better with the form that has been described as *comptus*. The specimens were all taken near Ft. Collins where we have done most of our collecting for *M. coccineipes*.

consperсus Scudd. This species occurs over the eastern plains and in the mountain parks of the eastern slope to an elevation of something over 8,000 feet. The species was found fairly common, for example, near Alder at an altitude of 8,500 feet on native grass land. It occurs most abundantly, however, on the grassy slopes of the foothills and upon the plains just outside the hills. While this locust has been found chiefly upon native grass-pasture land it has also been noted as feeding upon cabbages and alfalfa in moderate numbers. So the species is doubtless capable of adapting itself to a diet of cultivated plants if its supply of native food-plants should run short. It probably causes considerable damage where abundant upon native pasture land.

Our earliest capture of an adult of this species was at Greeley, July 13, 1898. But very few adults have been taken before Aug. 5th. Our latest capture was at Julesburg, Nov. 8, 1902.

We have taken specimens at the following points: Ft. Collins, Livermore, Windsor, Greeley, Julesburg, Boulder, Denver, Palmer Lake, Pueblo, Trinidad, Antonito, Alder, Salida and Buena Vista; and at altitudes varying between 4,500 and 8,500 feet. The high altitude specimens are smaller in size, darker in color and could easily be taken for a different species from the brownish testaceous form found in the lower altitudes.

The small males from high altitudes measure as small as 16 mm. in length while the largest from lower altitudes measure as high as 24 mm. The females measure between 18 mm. and 27 mm.

cuneatus Bruner. See *Melanoplus occidentalis.*

dawsoni Scudd. Our collections indicate that this species is confined to the foothills of the eastern slope of the mountains. It is not an abundant species but we have taken it from the border of the plains next the first foothills to an altitude of 8,000 feet. Specimens have been taken as far south as Palmer Lake. It is most common on the dry slopes of the lower foothills. The long winged form has not been taken.

Males vary in length between 14 mm. and 17 mm. and their elytra between 4.5 mm. and 6 mm. The females vary in length between 18 mm. and 20 mm. and their elytra between 5 mm. and 7 mm. Measurements upon 25 males and 31 females.

Specimens have been taken at Ft. Collins (at foothills), Dutch George's, Steamboat Springs, Pinewood, Boulder and Palmer Lake.

devastator Scudd. Two locusts taken at Steamboat Springs July 26th, 1891, were determined by Dr. Scudder as belonging to this species with a question mark attached. Altitude about 7,000 feet.

differentialis Uhl. This is an abundant and very destructive species in the lower altitudes of the State, especially where there is plenty of moisture. Except for the black markings of the posterior femora this species has no conspicuous markings but it varies much in color. In the warmer portions of the State the prevailing color is a light yellowish brown while in the higher and cooler portion the prevailing color is very much darker. In all places where the species occurs in the State there are occasional or frequent individuals that are black, except for yellow bands upon the legs, and sometimes light posterior lateral margins to the pronotum.

This locust is a very general feeder, particularly upon cultivated plants. Those we have noted are: alfalfa, corn, Kaffir corn, wheat, oats, leaves of apple, peach and plum and sugar beets.

The males taken vary between 27 mm. and 35 mm, and the females vary between 31 mm. and 42 mm. We have recorded the species from the following places: Ft. Collins, Windsor, Greeley, Merino, Julesburg, Loveland, Sterling, Laporte, Boulder, Pueblo, Colorado Springs, Canon City, Las-Animas, Rockyford, Lamar, Delta and Grand Junction. This species has been most abundant along the eastern portion of the State and at Grand Junction. We have not taken specimens above 5,500 feet altitude.

This species is rather late in maturing. A few adults were seen at Pueblo July 15th, 1901, and a few at Rockyford July 16th 1901 (Ball). The earliest adults at Ft.Collins were taken July 21, 1901. At Merino Aug. 8, 1902, females were not ready to oviposit. Females taken Nov. 11, 1902, still contained immature ova.

dimidipennis Brun. (See description following this article).

fasciatus Barnst. This species appears to be confined to the mountains and chiefly to high altitudes. Our specimens have come from twol ocations,Marshall Pass and Ward, at altitudes varying between 10,000 and 11,000 feet, except a single specimen taken in the foothills a few miles west of Ft. Collins at an altitude of 8,000 feet. I wonder if this mountain species can be identical with the *fasciatus* of the New England states. It is certainly a native of the high mountain ranges in Colorado where it occurs very sparingly.

The males vary between 15.5 mm. and 18 mm. in length and the females between 18 mm. and 21 mm.

All the specimens taken are short-winged, belonging to variety *curtus*.

femur-rubrum DeGeer. This is, next to *atlanis*, the most generally destributed of any species of *Melanoplus* in Colorado. Next to *bivittatus*, it is probably the most injurious species though *differentialis* is more injurious where it is most abundant. It occurs on both the eastern and the western slopes and in the mountains to an altitude of 8,000 feet. The species is extremely variable in color. The almost unicolorous fuscous-brown form that is common in the eastern states is not the prevailing form here. The abdomen and all of the under surface is usually distinctly yellow. The lower part of the

face, an area at the base of each antenna, a patch beneath and posterior to the compound eyes and a narrow line above each black post-ocular stripe, and often the posterior portion of the occiput,also,are yellow. Sometimes the entire head,except the compound eyes,the vertex and the post-ocular stripes,is yellow. The pronotum may be entirely dark fuscous with a broad black band on the prozona on either side, or the sides of the pronotum may be partly or entirely yellow outside of the black band of the prozona. The disk of the pronotum may be entirely yellow, or entirely rufous or it may be dark at the sides with a yellow or rufous median stripe of varying breadth. The femora may be yellowish shaded with dusky or they may be distinctly tinged with red. The hind femora may be dusky brown above with the lower half of the outer face yellow, or the outer face may be dusky brown throughout. In others the outer face is dusky brown with a yellow or even a reddish margin. In still others, and these are not uncommon, the dark parts of the femora are blue or bluish-green in color. In some the color is a deep steel blue. When these blue colors occur on the femora, the dark parts of head,thorax and elytra partake of the same tint. Those most highly colored with the blue often have the hind tibiæ tinted with the same color. These highly colored forms are among our handsomest grasshoppers and seem at first quite unlike the somber colored *femur-rubrum* as commonly described and seen in the east and yet there is so complete a gradation of forms between the extremes of coloration that I have not been able to separate out a distinct variety. It seems probable that these blue colored forms are what Dodge described as *plumbeus*. In fact he suggests that *plumbeus* may be only a local variety of *femur-rubrum*. At least I have been unable to find any characters that will hold to separate typical form of *plumbeus* from these highly colored forms of *femur-rubrum*.

The males we have taken vary between 17 mm. and 26 mm. in length and the females between 20 mm. and 26 mm. These are common variations. Occasionally a specimen is taken that seems abnormally small. This is especially true of occasional short-winged specimens that we have taken.

Short-winged form. We have taken specimens of a short-winged form of this species, mostly in shaded places. The elytra in these have been between 6 mm. and 7 mm. in length and reach a little beyond the middle of the abdomen. The males of this form have measured between 12 mm. and 16 mm. in length and the females about 18 mm. These were mostly taken by Prof. Ball.

The above is written up from 190 males and 100 females of the long-winged form and seven males and one female of the short-winged form.

The food-plants we have recorded for this species are: alfalfa, wheat, oats, corn, potatoes, beets, foliage of fruit trees and cabbage.

We have taken specimens at the following places: Ft. Collins, Laporte, Livermore, Virginia Dale, Windsor, Greeley, Merino, Ft. Morgan, Julesburg, Snyder, Orchard, Boulder, Denver, Palmer Lake, Pueblo, Canon City, Colorado Springs, LasAnimas, Rockyford, Lamar, Antonito, Salida, Gunnison, Ridgway, Delta, Paonia, Grand Junction, Palisades and Hayden.

The earliest that an adult has been found at Ft. Collins was June 26, 1901, (Ball). Ordinary years very few adults can be found before the 15th of July. Females taken Nov. 11, 1902, still contained immature ova.

flabellifer Scudd. See *occidentalis.*

flabellifer var. *brevipennis.* See description in following article.

flavidus Scudd. This is also a plains species and occurs sparingly in the southern portion of the State. It is abundant upon grass pastures along the foothills and upon the plains near Ft. Collins and has been taken feeding upon alfalfa, cabbages, leaves of plum and cherry trees and upon *Artemisia trifolia*, so that, whenever a food supply of native plants becomes scarce, this species is likely to become seriously injurious to cultivated crops.

This species is somewhat larger than *bowditchi*, the males ranging from 23 mm. to 26 mm. in length and the larger females measure as much as 32 mm. The antennæ of the males measure 14 mm. These dimensions are somewhat greater than those given for the types. We have taken adults at Ft. Collins from July 19th, 1902, till Sept. 19th, 1898.

Taken at the following points: Ft. Collins, Timnath, Greeley, Julesburg, and a single specimen at Lamar.

The furculæ of the male vary about the same as in *bowditchi.*

gillettei Scudd. Marshall Pass, Aug. 23, 1896 (Ac. 2260), and Aug. 27, 1899; Cameron Pass, Aug. 19 and 20, 1899; Little Beaver, July 17, 1898.

This species has been found at high altitudes only. It was fairly common Aug. 27th on Marshall Pass between

11,000 and 12,000 feet altitude and was taken between 10,500 and 12,500 feet in altitude. Food-plants not known.

glaucipes Scudd. The collection contains 16 males and 22 females taken at Wray, Pueblo and Nepesta. The males vary between 17 and 20 mm., and the females between 20 and 27 mm. in length. See *Melanoplus simplex*.

infantilis Scudd. This is the smallest of our Melanopli and is a mountain and high plains species in this State. It seems to prefer grassy areas in exposed places and may commonly be found in the grassy mountain parks to an altitude of 8,000 feet at least. We have not seen the species much higher than this. The earliest adults at Ft. Collins were taken June 21st, 1901 (Ball). The latest we have taken the species is Oct. 12th, 1898.

Our specimens vary in size as follows: Males from 13 mm. to 19 mm. and females from 15 mm. to 21 mm.

We have taken specimens at Ft. Collins, Laporte, Livermore, Dunkley, Idlewild, Dutch George's, Virginia Dale, North Park, Denver, Palmer Lake, Pueblo, Alder, Estes Park, Durango and Gunnison, and at Kimball, Neb. It doubtless occurs east across the plains of the northern portion of the State.

It is hardly abundant enough to be considered an injurious species in Colorado.

kennicottii Scudd. Marshall Pass, Aug. 27, 1899; Durango, Aug. 7, 1899; Chama (N. M.), Aug. 8, 1899; Ward, Aug. 30, 1899. The lowest we have taken this species was at about 6,500 feet feet at Durango. At Chama,(N.M.),it was taken at the station, 7,863 feet, while at Ward and at Marshall Pass specimens were taken between 10,000 and 11,000 feet altitude. The species has not been found abundant anywhere.

lakinus Scudd. This is distinctly a plains species occurring all over the eastern portions of the State to the first foothills. It is common on ground covered by native grasses upon which it is supposed to feed though we have no positive evidence upon this point. It has been noted as feeding upon sugar beets and Russian thistle (Ball) and is usually common where tumble-weeds grow.

The species occurs in both long-and short-winged forms, the latter being by far, more common. Out of the 225 specimens in the College collection there are 12 macropterous males and 7 macropterous females.

The males vary in length between 14 mm. and 23 mm. and the females between 20 mm. and 26 mm. The elytra in the brachypterous forms vary between 4 mm. and 7 mm. in length in both sexes.

The macropterous form has been taken at Ft. Collins, Julesburg, Holly and Pueblo. The short-winged form has been taken at Ft. Collins, Julesburg, Wray, Sterling, Greeley, Colorado Springs, Pueblo, Canon City, Trinidad, Nepesta, Rockyford, LaJunta, Lamar and Holly.

This species varies widely in size and coloration in Colorado. In some the yellowish-brown prevails, even upon the elytra and pronotum; in others a decided greenish-yellow tint occurs on the same parts. At the other extreme there are those that are quite uniformly dark fuscous so that even the dark bands of the femora are hardly discernable. I am unable to find any constant characters separating this species from type specimens of *M. marculentus* from Mexico that are in the College collection.

luridus Dodge. An abundant species in northern Colorado east of the mountains. It seems to be most numerous in the vicinity of the foothills but does not extend far into the hills. The native food-plant is *Artemisia dracunculoides*. The nymphs with their genæ and sides of the pronotum (except a white median line on the latter) black, make conspicuous objects upon the stems of the food-plant. This species takes readily to some of the cultivated plants also. We have noted it feeding upon alfalfa, cabbages and leaves of plum and apple trees.

In size the males vary between 19 mm. and 21 mm. and the females between 20 mm. and 26 mm. Measurements from 61 males and 24 females.

Adult males were just beginning to appear July 22 at Ft. Collins in 1901 (Ball). They were abundant at Laporte Sep. 30, 1899, and specimens have been taken at Ft. Collins as late as Oct. 23, 1901.

This species has also been noted as feeding upon *Bigelovia* (Ball).

But few females were ready to lay eggs Sep. 8, 1902 (Ball).

We have taken this species at the following places: Ft. Collins (abundant upon dry ground), Laporte, Livermore, Ft. Morgan, Colorado Springs and Boulder.

minor Scudd. This is not an abundant species in Colorado but occurs in moderate numbers in the north-eastern portion over

the plains and for a considerable distance into the foothills. In fact it seems to prefer the slopes of the lower foothills and the plains near them. We have found it in places rather common on alfalfa and have frequently noted the species upon blue-grass (*Agropyrum glaucum*) and rush-grass (*Sporobolus cryptandrus*).

This is also the earliest of the *Melanopli* to mature. We have taken adults fairly common at the foothills near Ft. Collins on June 6th, 1902 (Ball). The latest that we have taken adults is Aug. 22, 1902 at Ft. Collins. This species occurs as far south as Pueblo, at least. It has been taken at the following points: Ft. Collins, Laporte, Livermore, Julesburg, Wray, Denver, Palmer Lake and Pueblo.

Our males vary in size between 17 mm. and 20 mm. and the females between 23 mm. and 26 mm.

Specimens have been taken at an altitude of 7,000 feet in the foothills.

monticola Brun. Three males and one female from Windy Point, Pike's Peak, at an altitude of about 12,000 feet, Sep. 17th, 1903 (Cockerell).

occidentalis Thom. This is a common and wide spread species. It seems to occur over the entire plains region from north to south. It is common among the lower foothills and upon grassy areas in the mountains to an altitude of 8,000 feet, at least. In the lower altitudes the males vary commonly between 19 mm. and 22 mm. in length and the females between 19 mm. and 24 mm. Specimens taken at higher altitudes, as at Dolores, Durango and Buena Vista, are decidedly smaller and darker in color. The males from these higher altitudes measure between 15 mm. and 18 mm. and the females between 17 mm. and 19 mm.

Adults have been taken as early as June 17th at Ft. Collins, 1898, and at Lamar 1900 (Ball). At Ft. Collins there is very little mating before the first of August and males have been taken as late as September 12th. There is but one brood. Food-plant not known.

We have taken this species at Ft. Collins, Livermore, McCoy, Dutch George's, Wray, Sterling, Snyder, Greeley, Denver, Pueblo, Rockyford, Las Animas, Lamar, Trinidad, Buena Vista, Durango, Gunnison, Antonito and Dolores, and at Kimball and Stratton in Nebraska.

The cerci of the males of this species vary considerably in form, the extremes resembling very closely, if they

are not identical, with the forms described for *flabellifer* and *cuneatus*, but with such imperceptible gradations that I have been unable to recognize either of these species as separate from *occidentalis* in our collections.

The pevailing form of *cercus* in Colorado is that shown in Plate X, Fig. 6 of Dr. Scudder's "Revision of the Melanopli," and this is the form that agrees with Thomas' original description of *occidentalis*.

packardii Scudd. This is a common species over all the eastern portion of the State to the foothills and it also occurs in the grassy glades and mountain parks of the eastern slope to an altitude of 8,000 feet or more. It would be difficult to say whether the species is more abundant on the level prairie or upon the sides and summits of the low hills. It seems to be everywhere on land covered with native grasses, but that the grasses are its food-plants is an inference. This species is not uncommon in alfalfa fields and has been noted by us as feeding upon cabbages. The species is so large and abundant it must do considerable damage to native pasture land.

Males were just beginning to mature at Ft. Collins, June 29, 1901, and occasional adults were noticed in the same locality Oct. 8, 1902. (Ball.) Our adults were taken at Greeley June 24, 1899.

The species varies in Colorado from a light rusty brown to a rather dark brown with more or less distinct lighter stripes on the lateral margins of the dorsum of the pronotum. In some of the darker specimens these lines are obsolete.

In length, the males vary between 23 mm. and 29 mm. and the females between 23 mm. and 33 mm. Among the 127 specimens in the College collection there are 33 males and 21 females with blue hind tibiæ and 36 males and 37 females with red hind tibiæ.

This grasshopper has been taken in the following localities in Colorado: Ft. Collins, Dutch George's, Livermore, Julesburg, Sterling, Orchard, Wray, Greeley, Windsor, Estes Park, Boulder, Lafayette, Denver, Palmer Lake, Pinewood, Durango, Rockyford, Lamar and Holly.

regalis Dodge. A few specimens of this species were all taken by Mr. Ball. One specimen from Ft. Collins, August 14, and specimens from Holly, Lamar and LasAnimas bearing dates July 18 and September 8. Specimens determined by Prof. Bruner.

This is one of the handsomest of our Melanopli and is very different from the species of *Aeoloplus* that has been supposed to be Dodge's *regalis*.

This species might easily be mistaken for *sanguineous* Bruner.

sanguineus Brun. (See description in article following this). A few specimens only and all from the south-eastern portion of the State. The localities are Holly, Lamar, Las Animas and Rockyford. Dates, July 17th to Sep. 14th (Ball). In general appearance closely resembling *regalis*.

simplex Scudd. Two males have been taken in the Arkansas Valley, one at Holly, Sep. 8, 1898, and one at Nepesta, Aug. 6, 1900 (Ball). The first measures 17 mm. and the second 19 mm. Tegmina of male from Holly 8 mm. and of the one from Nepesta 13 mm. The latter specimen has blue hind tibiæ and may belong to *glaucipes*, but aside from the longer elytra and the different colors of the tibiæ, and the difference in size, the two specimens appear to be identical. This species seems a very close relative of *glaucipes* but in general appearance, as we have them determined, *glaucipes* is more slender and with the male abdomen nearly straight, while in *simplex* the male abdomen is strongly upturned at the end.

spretus Uhl. I cannot help suspecting that some of the reported occurences of this species have been from specimens of *atlanis*. During thirteen years of collecting in Colorado, and we have done a large amount of it, we have not taken a single specimen of this locust. I do not think it can have any permanent breeding ground within this State at present.

tristis Bruner. See description in article following this.

yarrowi Thom. A single pair were taken at Grand Junction Aug. 28, 1894. This species looks very much like *M. flavidus* with hind tibiæ red, or like a light colored specimen of *M. femoratus* without the pale stripes and not so robust. Length of male 25 mm. and of female 35 mm.

PHŒTALIOTES Scudder.

nebrascensis Thom. Another common species on grass land on the eastern plains of the State. Its food-plant,so far as our observations have gone, is blue-grass (*Agropyrum glaucum*). This specicies is rather late in maturing. On July 16, 1902 at Ft. Collins many nymphs but no adults were observed upon *Agropyrum*. On July 30th the adults were common. On Aug. 1st, 1901 at the same place it was noted that there were many nymphs and a few adults upon blue-grass. The adults

were still common Sep. 25th, 1898, near Ft.Collins (notes by Ball).

The males in the collection vary between 19 mm. and 23 mm. in length and the females measure from 23 mm. to 29 mm. in length. The elytra of the short-winged males vary between 5 mm. and 6.5 mm in length and those of the females between 5.5 mm. and 7.5 mm. in length.

A few specimens of the long-winged form (*volucris*) have been taken at Ft. Collins and one specimen was taken at Lamar.

We have taken the species at the following places: Ft. Collins, Greeley, Julesburg, Merino, Pueblo, Colorado Springs, Rockyford, Lamar and Holly.

DACTYLOTUM Charpenter.

pictum Thom. A fairly common species on the plains of the eastern portion of the State and occuring on dry, exposed areas for some distance within the foothills but not far. Its principle food-plant, according to Prof. Ball's notes, seems to be *Aster multiflora* though he has several times noted it feeding upon *Kalmia glauca* (American laurel). He has also seen it resting upon *Senecio Douglasi*, apparently as a food-plant, and we have found occasional specimens on alfalfa.

The bright coloration is very constant; males vary between 20 mm. and 24 mm. in length and the females between 29 mm. and 35 mm. The wings of the males vary between 4 mm. and 5 mm. and those of the females between 5 mm. and 6 mm. Taken at the following places: Ft. Collins, Laporte, Livermore, Wray, Pueblo, Rockyford, Lamar and Holly.

We have found the species abundant just outside the first foothills and have taken adults at Ft. Collins from July 26th to Sep. 30th.

Some New Colorado Orthoptera

BY LAWRENCE BRUNER.

Nemobius brevicaudus new species.

A medium sized, pale colored insect in which the female has an exceedingly short ovipositor, not much more than one-half as long as that of other species in which this member is described as greatly abbreviated. In general appearance perhaps most closely resembling *N. mormonius* Scudd. from Utah.

Pale testaceous with a few darker markings on head, pronotum and abdomen above. The pronotum a little narrower in front than behind, its surface sparsely adorned with rather stiff, not very long, dark colored bristles. Front and middle femora, as well as the front between the base of antennæ, likewise adorned with similar bristles. Tegmina half as long as abdomen, about as long as head and pronotum combined (♀), or nearly reaching its apex (♂) pale testaceous, without any definite darker markings. Ovipositor very short, straight, the apical half moderately coarsely toothed above, the extreme apex rather blunt. Anal stylets pale, slender, a little longer than hind tibiæ. Antennæ rather long and slender, testaceous basally, darker beyond.

Length of body, ♂, 8 mm., ♀, 8.5 mm.; of hind femora, ♂, 5 mm., ♀, 5.5 mm., of ovipositor, 1.85 mm.

Hábitat. 1 ♂, 1 ♀, Fort Collins, Colorado, October 4, 1901.

Ceuthophilus aridus new species.

Of a uniformly pale testaceous color, a trifle darker above than below, unadorned by darker mottlings, bands or blotches of any kind, a moderately slender insect with relatively smooth body and limbs. Eyes very dark brown or black, pyriform, the apex below. Front femora about one-fourth longer than pronotum, their front edge below provided with 1-2 very small spines in addition to a much longer preapical one, the lower posterior edge unarmed; anterior lower edge of middle pair armed with 3-4 and the posterior with 2-3 minute ones, the apex of the latter edge provided with an apical spine. Hind femora rather robust, without any decided genicular enlargments, a trifle over three times as long as greatest width, the apical half provided above with a number of dark raised points, and both the outer and inner lower carinæ furnished with numerous fine serrations, the sulcus rather narrow except near the apex. Hind tibiæ about one-sixth longer than femora, nearly straight and provided with four pairs of moderately strong gently diverging spines

in addition to the apical ones which are somewhat longer than the others; hind tarsi about one-third the length of the hind tibiæ, joint 2 twice as long as 3. Cerci rather slender, in length less than the greatest width of hind femora and abruptly bent downwards at about the middle.

Length of body, ♂, 12.25 mm., of pronotum, 3.45 mm., of fore femora, 4.2 mm., of hind femora. 9.65 mm., of hind tibiæ, 10.5 mm.

Habitat. A single ♂, November 17, at Grand Junction, Colorado.

On account of its uniform pale color this insect reminds one at first glance of all three of the following named species; viz., *C. alpinus* Scudd., *C. pallescens* Bruner, and *C. vinculatus* Scudd., from all of which, however, it differs in several important points as indicated in the description.

Ageneotettix occidentalis new species.

Very similar to both *A. scudderi* and *A. deorum*, but differing from both of these in its somewhat slenderer form and smaller size, as well as in the fewer (9) spines on the outer row of hind tibiæ, and in its normally somewhat abbreviated tegmina and wings.

Length of body, ♂, 10.5-13 mm., ♀, 15-18 mm.; of pronotum, ♂ 1.95-2.10 mm., ♀, 2-2.15 mm.; of tegmina, ♂, 7-9 mm., ♀, 9-10 mm.; of hind femora, ♂, 7.25-9 mm., ♀, 8.5-10 mm.

Habitat. Various localities in Colorado west of the main range, during the months of July, August and September (Collection Colorado Agricultural College).

Whether or not these are distinct, or only well marked geographical forms of a single rather variable species, is not certain now. However, the following brief synoptical table will show the main differences among these forms:

A[1]. Normally with somewhat abbreviated tegmina and wings in both sexes. Hind tibiæ nine spined in outer row..*occidentalis* n. sp.

A[2]. Normally with tegmina and wings hardly ever shorter than abdomen. Hind tibiæ ten or eleven-spined in outer row.

B[1]. Smaller, the tegmina and wings about equalling the abdomen in length even in ♂. Fastigium slightly acute-angled in male...*deorum* Scudd.

B[2]. Larger, the tegmina and wings slightly surpassing tip of the abdomen in ♂. Fastigium right angled or even more obtuse in male as well as in female...*scudderi* Bruner.

Encoptolophus coloradensis new species.

Somewhat resembling *E. sordidus* in general form but differing from it in a number of respects. The chief of these variations are a lower median carina of the pronotum in which the two sections are about equal in height, glaucous instead of fuliginous hind tibiæ, and a prevailingly pale grayish testaceous color with decided dark markings on tegmina, hind femora and posterior half of pronotal disc.

Head unusually large and gross, quite distinctly broader than the front edge of the pronotum and higher than the general depth of the body; the vertex between the eyes about as wide as the shortest diameter of the latter, the scutellum broadly pyriform, rather shallow and provided in its posterior half with a well defined longitudinal carina which is continuous over the occiput to the front edge of the pronotum; lateral foveolæ small, triangular, scarcely sulcate; frontal costa rather prominent, the sides evenly diverging downwards, quite deeply sulcate in the vicinity of the ocellus, the bounding walls heavy; antennæ about reach-

ing the hind edge of the pronotum. Pronotum somewhat strangulate in advance of the principal sulcus, the lateral carinæ not much interrupted though bowed, fairly prominent; the median carina straight, of medium height, cut a little in advance of its middle; hind edge of the disk somewhat obtuse-angled. Tegmina and wings about equalling the abdomen in length, the apex of former broadly rounded. Hind femora normal, not quite reaching the tip of the abdomen.

General color pale grayish testaceous, the sides of pronotum obscurely banded with dull black or brown, the disk of pronotum with the X-shaped pale marking of *sordidus*, *costalis* and *parvus*. Tegmina crossed with four heavy dark bands and marked basally with irregular small blotches. Hind femora decidedly trifasciate with fuscous externally; hind tibiæ largely glaucous, the base pale. Sutures of abdomen narrowly black.

Length of body, ♂, 19 mm., ♀, 28 mm.; of antennæ, ♂, 7 mm., ♀, 8 mm.; of pronotum, ♂, 4 mm., ♀, 5 mm.; of tegmina, ♂, 17, ♀, 20; of hind femora, ♂, 11 mm., ♀, 14 mm.

Habitat. Fort Collins, Colorado, August 14, a single ♀ (C. P. Gillette); same locality, 1 ♂, and 1 ♀ (L. Bruner).

Trimerotropis inconspicua new species.

A trifle under the medium size for the *vinculata* group to which it belongs, and at once recognized by its generally light color and comparatively narrow, but well defined, posteriorly converging tegmina bars, together with the pale disk of pronotum.

Head of moderate size, the eyes a trifle prominent and semiglobose. Vertex longer than wide and provided with a well-defined longitudinal carina. Antennæ dark brown annulated with testaceous, nearly or quite as long as hind femora. Pronotum rather flat on disk but provided with a net-work of low, smooth ridges which gives its surface a granular appearance; the anterior lobes very little tumid and furnished with a median carina which is but little more prominent than that on the hind lobe; posterior edge of disk right-angled in both sexes. Tegmina extending nearly one-third (♂) or only about one-fifth (♀) of their length beyond the tip of abdomen, the veinlets on basal half or two-thirds very numerous and a trifle coarse, thereby giving to that portion of these members a sort of granular appearance. Hind femora moderately slender, not quite reaching (♀) or a little surpassing (♂) the tip of abdomen.

General color very light cinero-ferruginous, with the usual dark-brown or blackish markings of the group to which it belongs. In some specimens the anterior portion of pronotum both on sides and disk are marked with clusters of small black flecks, but in others this portion is entirely pale—being relieved only by the brownish dots which adorn the carinæ of vertex, front, cheeks, pronotum, etc. The pale ferruginous tint which pervades the whole insect is due chiefly to the color of the bottom of punctuations which are well scattered over its surface. While the bands on tegmina are not solid they are quite prominent and made up of clusters of dark dots or by the infuscation of certain veinlets. On the basal portion these bands are narrower than usual and show a decided tendency towards converging posteriorly, while the apical portion is nearly destitute of markings save for the infuscation here and there of a few veinlets. Wings with their disks very pale greenish-yellow, crossed about the middle by a narrow fuliginous band which sends its anterior spur nearly one-half way to the base, the apical portion beyond the band perfectly transparent. Hind femora with lower sulcus yellow or at least with two pale bands. Hind tibiæ, except on extreme base where they are dark-brown, pale greenish-yellow, a little infuscated beyond the subbasal pale annulus and apically. Front and middle legs with well marked dusky annulations.

Length of body, ♂, 17 mm., ♀, 24-26 mm.; of antennæ, ♂, 10 mm., ♀, 10.5 mm.; of pronotum, ♂, 4 mm., ♀, 5.5 mm.; of tegmina, ♂, 18.5 mm., ♀, 24-25 mm.; of hind femora, ♂, 10-10.5 mm., ♀, 10.5-12 mm.

Habitat. Paonia, Palisades, Rifle and Dolores, Colorado, during the months of July and August.

In the McNeill table of species of Trimerotropis this insect will fall into the *vinculata* group with *salina*, *similis pallidipennis* and *longicornis* (The latter a new species described by E. M. Walker in Can. Ent. xxxiv, 4). That portion of the table may therefore be modified as follows:

f^1. Lower sulcus of posterior femora light, with one preapical black band, or black, with two light bands, one preapical and one median, the latter not merely interrupting the black on the edges of the sulcus, but in the bottom as well.

g^1. Fuscous band in its usual position in the middle of the wing. Spur extending less than half way to the base.

h^1. General color light cinereo-ferruginous. The bands of tegmina well marked and rather strongly converging towards the posterior edge............................ *inconspicua* n. sp.

h^2. General color dark fuscous brown, permitting little contrast in the bands of tegmina, the latter not markedly conconverging towards posterior edge.

i^1. Metazona scarcely more than one and one-half times as long as prozona. Fuscous band variable.

j^1. Fuscous bands of wings very broad, occupying nearly one third the length of the wings, apical portion with only a few fuscous dots........*salina* McNeill.

j^2. Fuscous bands of wings narrower, occupying less than a fifth of the lenght of the wings, apical portion rather strongly infuscated............... *longicornis* Walk.

i^2. Metazona twice as long as the prozona. Fuscous band rather narrow, occupying no more than a sixth or seventh of the length of the wings............. *similis* Scudd.

g^2. Fuscous band entirely beyond the middle of the wing, making the length of the disk equal to the width. Fuscous spur extending more than half way to the base....... *pallidipennis* Burm.

f^2. Lower sulcus of the posterior femora black, with but one preapical light band ....*vinculata*, *huroniana*, *collaris*, *fratercula*, *saxatilis*, and *sordida*.

Aeoloplus minor new species.

A small, slender, short-winged insect with pinkish or light purplish hind tibiæ, in which the supraanal plate of male resembles quite closely that of the longer-winged *Ae. tenuipennis* Scudder, from Arizona.

Head a little longer than the front edge of pronotum, the occiput somewhat ascending; eyes only moderately prominent, the vertex between them a little narrower than the frontal costa between the antennæ and deeply sulcate to upper end of costa, in both sexes; the latter scarcely sulcate even at the ocellus; antennæ short and slender, scarcely reaching hind edge of pronotum in either sex. Pronotum with the anterior lobes about equal, the disk smooth and evenly rounded, without a perceptible median carina; hind lobe slightly expanding posteriorly, the the surface punctulate and with a slight median carina, the hind edge broadly angulate. Tegmina and wings abbreviated, rather narrow and evenly tapering, reaching from the middle to three-fourths the length of abdomen. Hind femora robust and furnished at base with a large downward projecting tooth, reaching beyond the tip of abdomen in both sexes. Apical segments of male abdomen only slightly enlarged, the last ventral segment ending in a short, blunt, upward projecting point; cerci nearly as long as supraanal plate, evenly tapering on basal three-fourths, equal beyond, the apical portion gently bent inwards; supraanal plate subtriangular, the sides sinuose and having the apex produced and

rounded, the surface practically as descibed for *Ae. tenuipennis*. Valves of ovipositor slender, short.

General color testaceous, varied with the usual brown markings, in some specimens with an olivaceous tinge, especialy on tegmina and hind femora. Sides of basal abdominal segments and about base of supraanal plate and cerci dark brown or piceous. Posterior femora with the usual dusky bands which are some shade of olive or brownish olive, the genicular lobes and base of tibiæ a little darker, the latter decidedly pinkish or pale lilac, in some specimens changing to glaucous apically.

Length of body, ♂, 12 to 14 mm., ♀, 14 to 15 mm.; of pronotum, ♂, 3.1 mm., ♀, 3.85 mm.; of antenæ, ♂, 6 mm., ♀, 5 mm.; of tegmina, ♂, 6-7.5 mm., ♀, 6.5-7.5 mm.; of hind femora, ♂, 6 mm., ♀, 8 mm.

Habitat. ♂s and ♀s, Delta, Colorado, July 13, 1901.

The annexed portion of Scudder's table will show the affinities of the present species:

d^2. Cerci of male tapering almost uniformly through the basal three-fourths, only the apical half or less equal.

e^1. Larger. The tegmina and wings almost as long as abdomen. Hind tibiæ pale glaucous .... *plagosus* Scudd.

e^2. Smaller. Tegmina and wings from one-half to three-fourths as long as abdomen. Hind tibiæ pinkish or pale purplish. *minor* n. sp.

Hesperotettix Gillettei new species.

The distinguishing characters of the present species are the non-obscured transverse sulci of pronotum, the very narrow tegmina and bright salmon-colored anterior and middle, as well as the entire upper edge and pregenicular annulations of hind femora.

A bright grass-green locust with prominent white lines on thorax and along humeral angles of tegmina. In comparison with *Hesp. viridis* it is a somewhat slenderer insect of a more subdued and uniform color in which the pronotum is less expanded posteriorly and the tegmina and wings are decidedly narrower and show a variation in length from about one-half as long to a trifle exceeding that of the abdomen, a little longest in the males. It differs from its nearest ally, *Hesp. festivus*, in being of a much more uniformly cylindrical form and greenish color, in its more cylindrical pronotum and the heavier hind femora, the shorter and heavier cerci and the slightly more elevated and blunter apex of subanal plate of male abdomen.

Length of abdomen, ♂, 15 mm., ♀, 21 mm.; of pronotum, ♂, 3.5 mm., ♀, 5 mm.; of antennæ, ♂, 7.5 mm., ♀, 6.5 mm.; of tegmina, ♂, 6 to 11.5 mm., ♀, 7.5 to 16 mm.; of hind femora, ♂, 9 mm., ♀, 12 mm.

Habitat. Rifle, Colorado, July 25, ♂s and ♀s; Glenwood Springs, September 15; Delta, July 13 and Grand Junction, July 29, September 16.

Hesperotettix coloradensis new species.

A short-winged moderately robust insect which is quite closely related to *H. curtipennis*, but differing from it by its somewhat slenderer form, slenderer and shorter hind femora, the much shallower and less prominent transverse sulci of pronotum, the slenderer and longer valves of the ovipositor, and in lacking the pale border above dusky band on sides of pronotum. Otherwise the two forms are quite similar in general appearance.

Head small, eyes rather prominent; the vertex narrow, about as wide as basal (♀) or as second (♂) joint of antennæ, rather deeply sulcate in male, less so in female; frontal costa moderately broad, the sides nearly parallel, profoundly sulcate throughout. Antennæ with the joints somewhat depressed and heavier than usual in the male, in female nor-

mal. Pronotum subcylindrical, only gently widening behind, the anterior lobes smooth, only weakly punctate, and with ill-defined median carina; the hind lobe coarsely and rather closely punctate, its median carina quite evident, hind margin angulate. Tegmina lobate, lateral, their dorsal edges not touching. Hind femora slender, not quite reaching (♀) or gently surpassing (♂) the tip of abdomen. Apical portion of male abdomen slightly broadened, the extreme tip of last ventral segment gently raised above the level of apex; supraanal plate elongate, its sides upturned, the apex rounded and provided in middle with two rather coarse, blunt carinæ which begin near the base just in advance of the furculæ which are mere protuberances and meet a little before tip; cerci moderately long, about reaching the tip of supraanal plate, their apex attenuate and gently curved inward; valves of ovipositor slender, somewhat exserted.

General color grass-green varied with pale testaceous and dirty white. The sides of pronotum back of eyes streaked longitudinally with piceous bordered below by dirty white. Dorsum of thorax and abdomen with the usual light colored streak which frequently widens in the middle of anterior lobe of pronotum so as to form a sort of a diamond-shaped patch—a little interrupted just before reaching the hind edge. Hind femora internally and below testaceous, with scarcely any indication of the pregenicular ruddy annulation or tinge along upper edge.

Length of body, ♂, 16.5 mm., ♀, 24 mm.; of pronotum, ♂, 4 mm., ♀, 4.85 mm.; of antennæ, ♂ and ♀, 7 mm.; of hind femora, ♂, 9.5 mm., ♀, 10.5 mm.

Habitat. 1 ♂, Durango, Colorado, Aug. 7; 1 ♀, Dolores, Colo., Aug. 2. (Collection Colo. Agr. College).

With the addition of these two, and a third species from Florida, to those known to Scudder, we have his table of species considerably modified. This modified table is as follows:

ANALYTICAL KEY TO THE SPECIES OF HESPEROTETTIX.

*A*¹. Metazona of pronotum distinctly punctate on dorsum; prozona smooth, except sometimes feebly punctate on dorsum; nowhere rugulose.
- *b*¹. Pronotum highly and irregularly diversified in color, or else nearly devoid of markings of any kind, the dorsum nearly plane; tegmina in the diversified species marked with a white or pallid stripe on the division line between the discoidal and anal areas.
  - c¹. Transverse sulci of pronotum distinctly marked in black; hind femora with a distinct preginicular annulation.
    - *d*¹. Relatively slender-bodied, with slender femora; tegmina rarely as short as the body and then only in male; antennæ of male slender, distinctly longer than the head and pronotum together.......... *viridis* Thom.
    - *d*². Relatively stout-bodied, with stout femora; tegmina surpassing the body only in the males and then but slightly; antennæ of male coarse, scarcely longer than the head of pronotum together....... *meridionalis* Scudd.
  - c². Transverse sulci of pronotum not marked in strong colored contrast to surroundings.
    - *d*¹. Tegmina not abbreviate, about as long as the abdomen. Hind femora without red pregenicular annulation or only faint signs of one............ *festivus* Scudd.
    - *d*². Tegmina one-half or even a trifle longer than abdomen. Hind femora with a decided pregenicular annulation.................... *gillettei* n. sp.

b[2]. Pronotum diversified in color only by longitudinal stripes, the dorsum distinctly tectiform; tegmina without pale stripes (though they are occasionally indicated).

c[1]. Tegmina lobiform, little or no longer than the pronotum, their upper edges not attingent.

d[1]. General color dark brown, occasionally with a tinge of green; tegmina short ovate, distinctly shorter than the pronotum. .... *pacificus* Scudd.

d[2]. General color grass-green; tegmina long oval, scarcely shorter than the pronotum.

e[1]. Slender. Pronotum decidedly angulate behind, very preceptibly widening posteriorly. *coloradensis* n. sp.

e[2]. More robust. Pronotum with hind margin broadly rounded, of nearly equal width throughout. *curtipennis* Scudd.

c[2]. Tegmina fully developed or abbreviate, when the latter nearly or fully twice as long as pronotum, their upper edges overlapping.

d[1]. Tegmina and wings abbreviate, much shorter than the body. .... *brevipennis* Thom.

d[2]. Tegmina and wings distinctly surpassing the abdomen, or sometimes in the female only equalling it. *pratensis* Scudd.

A[2]. Pronotum decidedly tectiform; both prozona and metazona, both on dorsum and lateral lobes, equally and distinctly rugulose.

b[1]. Tegmina elongate, two to five times as long as broad, roundly acuminate at tip. .... *speciosus* Scudd.

b[2]. Tegmina ovate, at most one and one-half times as long as wide. .... *floridensis* Morse.

Melanoplus sanguineus new species.

Rather above the medium in size, a moderately robust insect having the general color aspect of *M. atlanis* and its allies, but differing from these species by its more robust hind femora which are rich blood-red inside and below, and in having the hind tibiæ very decidedly bluish-green as in *M. occidentalis* and some other species like *M. glaucipes* Scudder and *M. regalis* Dodge.

Head a little wider than the front edge of pronotum; occiput somewhat elevated above the plane of its disk, eyes fairly large but not very prominent even in the males; vertex a very little wider (♂), or about twice as wide (♀) as diameter of basal antennal joint; the fastigium roundly depressed and rather broadly and deeply sulcate; frontal costa about as wide above as vertex, broadening a trifle below and reaching the clypeus, punctuate above, gently sulcate at ocellus and below; antennæ a trifle longer than head and pronotum together. Pronotum with the sides of anterior lobes about parallel, hind lobe considerably expanding towards the rear, transverse sulci profound, the last about the middle; median carina faint on anterior lobes but prominent on posterior, the latter with its hind edge angulate. Anterior portion of male mesosternum provided with a large blunt protuberance. Tegmina rather narrow, tapering but little apically, reaching beyond the tips of hind femora in both sexes. Anterior and middle femora not greatly enlarged in male, the hind pair moderately robust, a little surpassing the abdomen in both sexes. Extremity of male abdomen neither clavate nor recurved, the subgenital plate short, the apex but little produced and not notched. Supraanal plate broadly triangular, the sides rounded and the apex a little produced, the middle furnished with a rather deep narrow groove which runs from the base nearly to the apex, a little wider and shallower near its termination, the sides undulate near base and projecting over the cerci. The latter nearly equal throughout, a little more than twice as long as greatest width, the apical half bent inwards and with their outer face slightly indented, the lower corner of apex obliquely docked.

Furcula consisting of a pair of moderately depressed, slender, parallel fingers equal and attingent on basal half, tapering for a short distance and slender and equal in outer third, slightly less than half as long as the supraanal plate.

General color varying from a pale testaceous to a dull wood brown, in the lighter individuals tinged above with ferruginous. Sides of head back of the eyes, and pronotum to last transverse incision provided with a well defined piceous band, in some specimens a trifle interrupted by light patches. Occiput usually provided with a similar dark band that begins at the vertex and extends backward to front edge of pronotum. Disk of latter usually pale, but sometimes becoming a little infuscated in middle. Tegmina provided with a discal row of fuscous dots in a pale field, beyond the basal half these also occupy the remainder of the wing. Hind femora provided above and on upper half of outer face with three dusky bands, the apex black preceded by a pale annulus, inner face and lower outer edge, together with lower sulcus, bright blood red; hind tibiæ bluish-green, the knees and genicular lobes of femora bluish-white.

Length of body, ♂, 22.5 mm., ♀, 25 mm.; of antennæ, ♂, 9.5 mm., ♀ 10 mm.; of pronotum, ♂, 5.1 mm., ♀, 5.5 mm.; tegmina, ♂, 20 mm., ♀, 21 mm.; of hind femora ♂, 13 mm., ♀, 14 mm.

Habitat. ♂s and ♀s Lamar and Las Animas, Colorado.

This insect would fall in Scudder's table for the separation of our species of Melanoplus near *bruneri*, *excelsus* and *utahensis*. The table would have to be modified for its reception as follows. (Bottom page 131):

g^2. Apical margin of subgenital plate of male conspicuously elevated above the lateral margins and sometimes greatly prolonged posteriorly; mesosternum of male in front of lobes with a central swelling, forming a blunt tubercle (5. Utahensis series).

- h^1. Apical margin of subgenital plate of male entire; lobes of furcula not exceptionally broad.
  - i^1. Subgenital plate only moderately prolonged. ***sanguineus*** n. sp.
  - i^2. Subgenital plate greatly but not excessively prolonged.
    - j^1. Interval between mesosternal lobes of male more than twice as long as broad, of female a little longer than broad; male cerci more than twice as long as broad; apical margin of subgenital plate of male, as seen from behind, subtruncate .... ***bruneri*** Scudd.
    - j^2. Interval between mesosternal lobes of male much less than twice as long as broad; of female transverse; male cerci less than twice as long as broad; apical margin of subgenital plate of male, as seen from behind, rounded. ***excelsus*** Scudd.
- h^2. Apical margin of subgenital plate of male deeply notched on either side of middle; lobes of furcula exceptionally broad, subequal throughout; subgenital plate excessively prolonged. ***utahensis*** Scudd.

Melanoplus tristis new species.

A rather small, slender, short-winged insect that bears a strong resemblance to *M. artemisiæ* but which more properly belongs to the Aridus series since it has the cerci and furcula of the male as found in the last named species. Entire insect quite strongly hirsute or pilose.

General color dark reddish brown, varied with darker brown and piceous. Head about as wide (♀) or a little wider (♂) than the front edge of the pronotum, the occiput a little raised above the plane of the latter; eyes large and quite prominent, sub-globular in the male, considerably less prominent and with the anterior edge decidedly straight in

female; vertex a trifle narrower (♂) or somewhat wider (♀) than the basal antennal joint, roundly depressed and quite deeply sulcate with the lateral carinæ rather coarse; frontal costa prominent, plain, the sides nearly parallel, a little wider than the vertex between the eyes in both sexes and reaching the clypeus. Antennæ slender, of moderate length, about reaching, ♀, or somewhat surpassing, ♂, the tip of pronotum. The latter with the sides of anterior lobes somewhat tumescent in ♂, smooth in ♀, no wider at last transverse incision than in front, the dusky band at sides furnished near the center above with a light patch, the posterior lobe a little the shorter, expanding and broadly rounded behind, its entire surface quite profusely punctate; median carina nearly equally prominent throughout. Prosternal spine coarse, conical, moderately long, directed a little to the rear and with the apex blunt. Tegmina lateral, elongate oval, reaching to or a little beyond the apex of the first abdominal segment. Abdomen with the sides strongly piceous, especially in the ♂s. Hind femora rather slender, not quite reaching (♀) or a little surpassing (♂) tip of abdomen, flavous inside and below, crossed on upper half by two dusky bands, the apex also dark; middle and front femora only moderately swollen or obese in males; hind tibiæ dull plumbeous, profusely hirsute. Apical portion of male abdomen only gently club-shaped, the tip very little upturned, the subanal plate entire at apex, in nowise notched or produced; supraanal plate triangular, about equally long and broad, the sides straight, the tip angulate; the furcula as described and figured for *M. aridus* Scudd. (Pl. xiv, fig. 3); cerci also as in that species, except, perhaps, that they may be slightly longer in proportion and a little more bent inwards on their outer half.

Length of body, ♂, 13.5 mm., ♀, 18-20 mm.; of antennæ, ♂, 7 mm., ♀, 6.5 mm.; of pronotum, ♂, 3.1 mm., ♀, 4 mm.; of tegmina, ♂, 2.6 mm., ♀, 3 mm.; of hind femora, ♂, 8 mm., ♀, 9 mm.;.

Habitat. Antonita, Dolores and Durango, Colo., 3 ♂s and 5 ♀s August (Collection Colo. Agr. College).

In order that the position of this species may be more clearly indicated the following portion of Scudder's table is modified so as to include it and is here appended:

g^1. Cerci of male long and very slender, in the middle not one-half the width of the frontal costa, last dorsal segment of male with a pair of strongly oblique submedian sulci outside the furcula; subgenital plate not elevated apically (3. Aridus series).

- h^1. Hind margin of pronotum truncato-emarginate; disk of metazona fully twice as broad as long; tegmina relatively slender, widely distant.
  - i^1. Disk of pronotum coarsely and uniformly punctate; cerci of male apically enlarged and inferiorly accuminate at apex. *humphreysii* Thom.
  - i^2. Disk of prozona coarsely punctate only along anterior margin; cerci of male apically equal, round at tip. *nitidus* Scudd.
- h^2. Hind margin of pronotum obtuse angulate or broadly rounded; disk of metazona less than twice as broad as long; tegmina variable.
  - i^1. Larger (♂ 17.5 mm.); tegmina relatively broad, approximate, at least in the male.................................... *aridus* Scudd.
  - i^2. Smaller (13.5 mm.); tegmina quite slender, lateral, and greatly separated above in both sexes................. *tristis* n. sp.

Melanoplus flabellifer brevipennis new variety.

The specimens before me, eight in number, and coming from Paonia and Palisades in western Colorado agree quite well with the general

description of *M. flabellifer*, only that all of them lack the fully developed tegmina and wings of that insect. The specimens from Palisades are decidedly tinged with rufous, while those collected at Paonia are cinero-plumbeous as indicated for the normally long-winged form.

Length of body, ♂, 14-16 mm., ♀, 21 mm.; of antennæ, ♂, 7.5 mm., ♀, 7 mm.; of tegmina, ♂, 5.5 mm., ♀, 7 mm.; of hind femora, ♂, 8.5-9 mm., ♀, 10-11 mm.

Habitat. 4 ♂s and 1 ♀, Palisades, Colorado, July 8, 1901; 2 ♂s and 1 ♀, Paonia, Colorado, September 20, 1903, (Collection Colorado Agricultural College).

The following synoptic table which has been somewhat modified from Scudder's (Revis. Melanopli, pp. 124 and 130, and Suppl. p. 160) will give at a glance the characters separating the various recognized forms belonging to the series:

d^1. Cerci of male very broad and short, not more than twice as long as the middle breadth, and broadly rounded at apex. (2. Flabellifer series.)
- e^1. Tegmina fully developed.
  - f^1. Cerci of male twice as broad in broadest as in narrowest portion.
    - g^1. Subgenital plate of male with a distinct though minute independent apical tubercle..........*occidentalis* Thom.
    - g^2. Subgenital plate of male with only one obscure trace of apical tubercle..............................*cuneatus* Scudd.
  - f^2. Cerci of male with no striking inequality in breadth. *flabellifer* Scudd.
- e^2. Tegmina more or less abbreviated.
  - f^1. Tegmina about half as long as the abdomen and much longer than the pronotum.
    - g^1. Cerci of male broadly longitudinally sulcate apically, as in flabellifer.......................*flabellifer brevipennis* n. var.
    - g^2. Cerci of male not longitudinally sulcate apically.
      - h^1. Interval between mesosternal lobes of male twice as broad posteriorly as anteriorly, the inner margins of the lobes regularly divergent; interval in female longer than broad; cerci of male but little longer than broad..............................*discolor* Scudd.
      - h^2 Interval between mesosternal lobes of male nearly equal breadth in front and behind, the inner margins of the lobes convex; interval in female transverse; cerci of male nearly twice as long as broad. · *simplex* Scudd.
  - f^2. Tegmina shorter than pronotum.
    - g^1. Furcula of male only as long as the last dorsal segment; cerci in apical half equal and deeply sulcate longitudinally, so as to appear bent at right angles. *rileyanus* Scudd.
    - g^2. Furcula one-fifth as long as supraanal plate; cerci in apical half tapering, not sulcate ....*blandus* Scudd.

Melanoplus dimidipennis new species.

A brachypterous insect the size of which is slightly below the medium and in which the tegmina and wings reach a trifle beyond the middle of the abdomen. Legs, under parts, and abdomen very light colored, the latter almost white except the two basal segments which for the most part are black on sides and above. Pleuræ and upper half of sides of front lobe of pronotum also very strongly marked with fuscous, their ground color along with greater portion of head light plumbeous. Hind tibiæ dirty yellowish-white with a greenish tinge.

Entire insect sparsely clothed with rather long erect light-colored hairs. Head a little wider than front edge of pronotum, the eyes only moderately prominent, a trifle longer than the cheeks below them; vertex rather broad, nearly twice the diameter of basal joint of antennæ, the fastigium shallowly but broadly sulcate, depressed and roundly uniting with upper extremity of the broad prominent frontal costa, the latter with straight edges and expanding but little below where it reaches the clypeus, broadly sulcate at ocellus and below and with a few scattered punctures above. Antennæ a little longer than combined length of head and pronotum. Pronotum with the anterior lobes a very little longer than the hind lobe, smooth and shining, the sides parallel; hind lobe diverging posteriorly, the surface profusely punctate, the hind margins of disk broadly angulate; median carina quite conspicuous on posterior lobe, almost obliterated on anterior lobes; transverse sulcus rather prominent, especially the posterior one which is profound and nearly straight. Prosternal spine rather long, fairly stout, regularly pyramidal, straight and with the apex rounded. Space between mesosternal lobes about half again as long as broad, divergent behind. Anterior and middle femora not especially heavy; the hind pair somewhat robust. Apical portion of ♂ abdomen very little or not at all enlarged; subgenital plate longer than wide, directed backward and gently upward, the extreme apex a little produced, entire but with the surface just before it depressed so as to give it the appearance of being notched as in atlanis and allies; supraanal plate broadly triangular, the sides sinuate and with the edges on basal half raised, the middle provided with two rather prominent nearly parallel carinæ inclosing a profound longitudinal channel which reaches from the base nearly to the apex, but which is interrupted a little beyond the middle by a low cross ridge joining the bounding walls. Marginal apophyses a little longer than width of preceeding segment, evenly tapering to a point, their bases touching, directed backwards and outwards so that their tips cross beyond the outer edge of the walls of central fovea of plate. Cerci about twice as long as broad, of nearly equal width, their lower outer edge gently truncate and the apex rounded, directed backward and inward.

Length of body, ♂, 18 mm.; of pronotum, 3.4 mm.; of antennæ, 7 mm.; of tegmina, 8 mm.; of hind femora, 10.25 mm.

Habitat. Fort Collins, Colorado, a single ♂ on August 16th.

By the use of Scudder's table for separating the species of Melanoplus as published in his "Revision of the Melanopli" this insect seems to come near *M. dawsoni*. In the characters of the tip of male abdomen it reminds one a little of *M. intermedius*, but other characteristics throw it out of the *atlanis* group.

The Bees of the Genus Nomada Found in Colorado,

With a Table to Separate All the Species of the Rocky Mountains.

BY T. D. A. COCKERELL.

When I undertook to work up the species of *Nomada* contained in the collection of the Colorado Agricultural College, I supposed that I should find a few new ones, but that the great majority would be well-known forms long ago discovered by Morrison, Ridings, and others. I find that the collection contains 29 species and varieties, and of these no less that 15 are new. Two others represent undescribed sexes of species previously known. This result serves to indicate the richness of the Agricultural College collection in rare and new forms, and the great value of the material gathered together by Professor Gillette and his associates. I have included in the table of species all those known to occur in Montana, Wyoming, Colorado and New Mexico. Some synonyms and doubtful records have been omitted. Our knowledge of the more northern species, from Wyoming and Montana, is exceedingly incomplete, but it is perhaps not without significance that the few species known from these states all range eastward. The species of Colorado, on the other hand, appear to represent a largely endemic fauna, though some eastern elements appear, particularly in the north. It is possible to separate the species into three groups, those which belong to the Rocky Mountain fauna proper,

those which are modified representatives of eastern species, and have probably reached Colorado in comparatively recent times, and those which are identical with species found east of the plains. Examples are as follows:

(1.) Rocky Mountain Fauna.—*N. rubrella*, *schwarzi*, *martinella*, *scita*, *grandis*, *civilis*, *etc.*

(2.) Modified eastern types.—*N. lepida*, *dacotana*, *vegana*, *zebrata*, *luteopicta.*

(3.) Typical eastern species.—*N. bella*, *albofasciata*, *cuneata superba*, *vincta.*

A few appear to be modifications of northwestern types; such are *taraxacella*, *pecosensis*, and possibly a few others. How far the species extend westward through Utah, etc., cannot be stated, owing to our almost complete ignorance of the *Nomadæ* of that region; but the California *Nomada*-fauna is very distinct from that of Colorado, and the comparatively few species seen from Nevada indicate the extension of the Californian fauna,at least in part, into that state. The same indications exist for Idaho.

The *Nomadæ* of the mountains of northern New Mexico naturally resemble those of Colorado to a considerable extent, but our present lists show a rather surprising amount of difference, perhaps mainly the result of inadequate collecting. The species of southern New Mexico are different, and belong to a southwestern fauna which no doubt extends into Arizona and northern Mexico, though no knowledge of the *Nomadæ* of those regions exists, excepting a single record from Juarez in Chihuahua.

It is hoped that the present paper will facilitate the study of *Nomada* in Colorado. The genus offers a very excellent field for research, and I venture to hope that some advanced student of the Agricultural College will interest himself in it. Undoubtedly more new species await discovery, while the habits of none of the species have been investigated. Very many species are known only in one sex, and there are probably some cases in which the opposite sexes of the same species have been described as distinct.

As is well known, *Nomada* is parasitic in the nests of other bees, principally *Andrena* and *Halictus*. This parasitism should be carefully studied, and it is necessary to breed the bees from the nests in order to fully establish it. It is difficult for me to believe that the same species of *Nomada* can be parasitic in nests of both *Andrena* and *Eucera*, as has been reported of *N. alternata* and *N. agrestis*; or in nests of both *Halictus* and *Colletes* as is recorded of *N. furva*.

TABLE FOR THE DETERMINATION OF THE SPECIES.

Vertex and mesothorax smooth and shining; male entirely black, females with a red abdomen (Montana)........grindelia Ckll.
Not so, never entirely black .... 1.

1. Normally with only two submarginal cells; abdomen red with yellow bands, first segment red without a band (Montana)..**obliterata** Cress.
   Normally with three submarginal cells............................2
2. Very large and robust, over 13 mm. long, red with abundant yellow markings ....3.
   Smaller, usually much smaller ....4.
3. Basal nervure considerably basad of transverse medial (Colo.)...**grandis** Cress.
   Basal nervure meeting transverse medial (Colo.)...... **magnifica** Ckll.
4. Mandibles bidentate ....5.
   Mandibles simple..14.
5. Males..6.
   Females..12.
6. Tegulæ more or less yellow; scutellum usually with yellow spots; abdomen with yellow bands (Colo.)............**lepida** Cress.
   Tegulæ red; scutellum black or red...................................7.
7. Thorax red marked with black...8.
   Thorax black, with or without red spot on the scutellum..........10.
8. Length about 7 mm.; light markings creamy white; metathorax red with a central black mark. (Colo.)........**rubrella** Ckll.
   Size larger; abdominal markings strongly yellow; metathorax entirely black...9.
9. Third antennal joint long; second submarginal cell broad above. (Colo.) ....**schwarzi** Ckll.
   Third antennal joint shorter; second submarginal cell narrow above (N. M.)..............................**schwarzi contractula** Ckll.
10. Size larger, length 9 to 10 mm., abdomen with yellow bands. (Colo.)..**bella** Cress.
    Size smaller .. ..11.
11. Abdomen with white bands. (Colo.).... ....**albofasciata** Smith.
    Abdomen with yellow spots or bands. (Colo.)..........**cuneata** (Rob.)
12. Larger, 10 mm. long or over. (Colo.) . ...**bella** Cress.
    Smaller, 8 or 9 mm. long...13.
13. Red of abdomen dark. (Colo.)..............................**cuneata** (Rob.)
    Red of abdomen light. (Colo.) ....**lepida** Cress.
14. Anterior coxæ strongly spined; abdomen strongly punctured......15.
    Anterior coxæ not or hardly spined; abdomen usually very minutely or not distinctly punctured.............................35.
15. Males..16.
    Females ....26.
16. Apex of abdomen entire; supraclypeal mark surrounded by black. (N. M.)..**lippiæ** Ckll.
    Apex of abdomen notched, though sometines feebly.... ....17.
17. Flagellum with a light median area, on each side of which is black...18.
    Flagellum ordinary, not so colored....................................21.
18. Tegulæ pale yellow or whitish; supraclypeal mark present.......19.
    Tegulæ deep ferruginous; ground-color of abdomen nearly all red. (Colo., Mont.).... ....**americana dacotana** Ckll.
19. First abdominal segment largely red, without light markings. (N. M.) ....**sophiarum** Ckll.
    First abdominal segment black or almost, with a narrowly interrupted cream-colored band...20
20. Abdomen comparatively narrow; legs clear light red. (Colo.)..**scita** Cress.
    Abdomen broad; legs darker. (Colo.)...................**martinella** Ckll.
21. Metathorax with yellow marks. (Colo., N. M.)........**vegana** (Ckll.)
    Metathorax without yellow marks.....................................22
22. Mesothorax reddish, size rather large; wings dark. (Colo.) ....**lamarensis** Ckll.
    Mesothorax entirely black, size smaller 23

23. Labrum entirely light red; light markings primrose-yellow; wings clear, strongly clouded at apex. (Colo.).......... **uhleri** Ckll.
Labrum yellowish-white. (Colo.)... .... **snowi** Cress.
Labrum blackish, or with a large black spot..........................24

24. Light markings white; flies in spring. (N. M.).......... **vierecki** Ckll.
Light markings yellow; fly in middle and late summer 25

25. Ventral surface of abdomen with two light bands. (N. M.) **crucis** Ckll.
Ventral surface of abdomen dark with only minute light marks (N. M.)........... .... **neomexicana** Ckll.

26. Abdomen red, without light bands...................................27.
Abdomen with light bands...... ....28.

27. Flagellum clear red. (N. M., Colo.)...................... **martinella** Ckll.
Flagellum strongly dusky. (Colo., Mont.) .... **americana dacotana** Ckll.

28. Mesothorax reddish (here expect the unknown ♀ of **lamarensis** Ckll.)
Mesothorax black, with little if any red...............................29.

29. Abdomen red with white bands ....30.
Not so, ground-color of abdomen mainly or wholly black.........31.

30. Mesothorax densely punctured. (Colo.)................... **ridingsii** Cress.
Mesothorax with well-separated punctures on a shining ground. (N. M.)................................... **vierecki** Ckll. var.

31. Lateral face-markings white or yellowish white. ....32.
Lateral face-markings yellow............................ 33.

32. Mesothorax densely punctured (Colo.)................. **snowi** Cress.
Mesothorax sparcely punctured on a shining ground (N. M.) .... **vierecki** Ckll.

33. Mesothorax with well separated punctures on a shining ground; ground color of first abdominal segment red (Colo.).. **vegana nitescens** Ckll.
Mesothorax densely punctured........................... .....34.

34. Metathorax with yellow spots (Colo., N. M.)............ **vegana** Ckll.
Metathorax without yellow spots (N. M.) .... **neomexicana** Ckll.

35. Abdomen with numerous entire (or some slightly interrupted) light bands. ....36.
Abdomen with light bands, more or less widely interrupted, at least on some of the segments................................59.
Abdomen red, with small yellow spots (sometimes bands on apical segments) or no light markings............................ 66.

36. Abdominal bands white or yellowish-white; no light markings on head or thorax; venter of abdomen ferruginous, immaculate ....37.
Abdominal bands yellow...38.

37. Scutellum strongly bilobate; wings paler (Colo.)........ **parata** Cress.
Scutellum not strongly bilobate; wings darker (Colo.). .**munda** Cress.

38. Legs yellow and black, without very much red.....................39.
Legs wholly or mainly red, or red and yellow...................... 40.

39. Smaller; third antennal joint shorter than fourth on the under (light) side (Colo.)................................... **civilis** Cress.
Larger; third antennal joint longer than fourth on the under side (N. M.).. **pecosensis** (Ckll.)

40. First abdominal segment without yellow; ♂s.......................41.
First abdominal segment with yellow................................43.

41. First abdominal segment black; scutellum black (N. M.) **ruidosensis** Ckll.
First abdominal segment red and black ....42.

42. Size larger, scutellum red (Colo.)...................... **coloradensis** Ckll.
Size small, scutellum black with small light spots (Colo.) .... **coloradella** Ckll.

43. First abdominal segment black and red, with a yellow spot on each extreme lateral margin; flagellum stout, third antennal joint shorter than fourth; basal nervure basad of transverse-medial. ....44.
First abdominal segment with a yellow band, entire or interrupted ....45.

44. Flies in June; a good deal of yellow on head and thorax (Colo.) .... **crawfordi** Ckll.
Flies in May; no yellow on head and thorax (Colo.) ... **collinsiana** Ckll.

45. Metathorax ferruginous and black, without any yellow; ♂s .... 46.
Metathorax entirely black .... 47.
Metathorax black with rather small light spots; lateral face-marks broad, but not or hardly going above level of antennæ; apical plate of abdomen more or less notched; ♂s ..... 51.
Metathorax with two large yellow (or yellow and red) spots .... 52.

46. Metathorax black without much ferruginous; scutellum and postscutellum yellow; apical plate of abdomen entire; flies in August (N. M.) .... **xanthophila** Ckll.
Metathorax with more red; scutellum red, postscutellum yellowish; size smaller; apical plate of abdomen deeply notched (Colo.) .... **libata** Cress.

47. Size larger; tegulæ yellow; apical plate of ♂ abdomen entire (Colo., Wyo.) .... **superba** Cress.
Size much smaller .... 48.

48. Tegulæ yellow (Colo) .... **luteopicta** Ckll.
Tegulæ ferruginous .... 49.

49. Head and thorax with much red; larger; flies in sping; ♀ (N. M.) .... **placitensis** Ckll.
Head and thorax without red; smaller; apical plate of abdomen notched; ♂s .... 50.

50. Antennæ very long, denticulate beneath; fourth joint very long, at least twice as long as third on upper side (N. M., Colo.) .... **fragilis** Cress.
Antennæ not so long, not denticulate beneath; fourth joint not nearly twice length of third on upper side (Colo.) **pallidella** Ckll.

51. Supraclypeal mark present; metathorax with four reddish or yellowish spots, two being on the enclosure (Mont.) ... **elrodi** Ckll.
Supraclypeal mark absent; metathorax with two small oval yellow spots (Colo.) .... **gillettei** Ckll.

52. Basal nervure meeting transverse-medial or falling short of it; species (at least **vincta** and **zebrata**) flying in late summer and early fall .... 53.
Basal nervure beginning decidedly (often greatly) basad of transverse-medial .... 54.

53. Apical plate of ♂ abdomen entire; mesothorax of ♂ wholly black, or with very narrow reddish lateral margins, of ♀ black or red and black (Colo.) .... **vincta** Say.
Apical plate of ♂ abdomen slightly notched; mesothorax of ♂ with yellow lateral margins, of ♀ red (Colo., N. M.) **zebrata** Cress.
♂ unknown; mesothorax of ♀ black with yellow lateral margins; thorax narrower than in **zebrata**; yellow of metathorax intruding on enclosure (which is not the case in **vincta** or **zebrata**); third antennal joint considerably shorter than fourth (it is considerably longer than fourth in **zebrata** and **vincta**) (Colo.) .... **perivincta** Ckll.

54. Mesothorax black, with the anterior lateral corners red; apical plate of abdomen truncate, not appreciably emarginate; sides of metathoracic enclosure yellowish; ♂ (Colo.) .... **agynia** Ckll.
Mesothorax red, with or without a black band; ♀s .... 55.

55. Flagellum strongly blackened at end, mesothorax with a broad median black band; scutellum yellow without a median dark stripe or shade; basal nervure a short distance basad of transverse-medial; third antennal joint a little shorter than fourth (Colo.) ...... **perivincta** var. **semirufula** Ckll.
Flagellum red, not blackened at end .... 56.

56. Ventral surface of abdomen yellow, with narrow red bands; scutellum at least mostly yellow .... 57.

Ventral surface of abdomen red banded with yellow; third antennal joint shorter than fourth ....58.

57. Third antennal joint long; fourth considerably longer than fifth (Colo.)............. ....**morrisoni** var. **flagellaris** Ckll.

Third antennal joint shorter; fourth scarcely longer than fifth (Colo.)..**morrisoni** Cress.

58. Scutellum prominent, entirely red; tegulæ strongly punctured; third antennal joint much shorter than fourth (Colo.)..**rhodoxantha** Ckll.

Scutellum not prominent, with a yellow band at base; tegulæ smooth and shining; third antennal joint a little shorter than fourth (Colo.)...................................**dilucida** Cress.

59. Markings white or cream-color.............. ....60.

Markings yellow..62.

60. Ferruginous species; third antennal joint much longer than fourth (N. M.) .... **gutierreziæ** Ckll.

Black or red and black species ....61.

61. Scutellum black with two cream-colored spots; head and thorax without red; third antennal joint slightly longer than fourth; ♂ (N. M.)..................................**aquilarum** Ckll.

Scutellum ferruginous; thorax with much red in both sexes, third antennal joint much shorter than fourth (Colo.) **accepta** Cress.

62. ♂s; head and thorax black.............. ....63.

♀s; head and thorax red, usually marked with black...............64.

63. Smaller, length not over 8 mm.; scutellum black; upper half of clypeus black (N. M.) ....**beulahensis** Ckll.

Larger, length 10 mm.; scutellum red; clypeus yellow (Colo) ....**vicinalis** Cress.

64. Tubercles and postscutellum yellow; venter of abdomen largely yellow (Colo.)..**alpha** Ckll.

Tubercles and postscutellum red; venter of abdomen red without yellow...65.

65. Front marked with black; a black stripe on mesothorax; apex of flagellum fuscous; second abdominal segment with yellow lateral spots, third and fourth with bands (Colo.) ....**libata** Cress.

Front wholly red; no black stripe on mesothorax; flagellum wholly red; second and third abdominal segments with large wedge-shaped yellow marks, fourth with a band interrupted on each side (Colo.)... ....**coloradensis** Ckll.

66. Head and thorax black, abdomen black and rufous................67.

Head red marked with black; thorax black, a large mark on each side of mesothorax, the scutellums and most of pleura, red; clypeus yellow; abdomen without yellow; ♂ (Colo.)..**adducta** Cress.

Head and thorax red; clypeus red.....................................68.

67. Clypeus reddish; legs rufous; basal nervure a short distance basad of transverse-medial; third antennal joint a little longer than fourth (N. M.)........... ....**pennigera** Ckll.

Clypeus black; legs black (N. M.)......................**sidæfloris** (Ckll.)

68. Larger, about 7 or 8 mm. long; second abdominal segment with yellow spots...69.

Smaller, about 6 mm. long ....71.

69. Lower anterior orbits very narrowly yellow; third antennal joint very much shorter than fourth (N. M.)......**taraxacella** (Ckll.)

Lower anterior orbits not yellow................. ....70.

70. Fourth and fifth abdominal segments with yellow bands, not nearly reaching lateral margins; third antennal joint nearly as long as fourth (Colo.)..................... **luteopicta** Ckll.

Fourth and fifth abdominal segments without yellow bands; third antennal joint much shorter than fourth (Colo.)....**sayi** Rob.

71. Abdomen red without yellow spots; scape stouter and lighter; metathorax without a black band (Colo.)........**rhodosomella** (Ckll.)

Abdomen with spots; scape darker and more slender; metathorax with a black band (Colo.) .... **coloradella** **Ckll.**

In addition to the species recorded in the table, *Nomada (Micronomada) putnami*, Cress., *N. (Holonomada) affabilis*, Cress., *N. (Xanthidium) citrina*, Cress., and *N. (Nomada* s. str.*) pygmæa*, Cress., have been recorded from Colorado, but the records appear to require confirmation. The first three are indicated in comparison with Rocky Mountain species in tables in Proc. Acad. Nat. Sci. Phila., 1903, pp. 581, 582 and 609. For *N. affabilis* also see Robertson, Canadian Entomologist, 1903, p. 177. *N. pygmæa* (♂) is about six mm. long, mandibles simple; clypeus, a spot above it, labrum, mandibles and face narrowly on each side of clypeus, yellow; orbits ferruginous; abdomen granular.

DESCRIPTIONS AND NOTES.

Nomada (**Gnathias**) **lepida,** Cresson.

Evidently very common at Fort Collins, Colorado, numerous specimens of both sexes sent by Prof. Gillette. The dates are from May 8 to 17.

The insect which I described (Proc. Acad. Nat. Sci. Phila., 1903 p. 600) as the probable ♀ of *N. schwarzi*, is really the ♀ of *lepida*.

Nomada (**Gnathias**) **cuneata,** (Robertson).

A ♂ (sent by Prof. Gillette) was collected at Fort Collins, foothills, May 10, 1900, by E. S. G. Titus. Others seem intermediate between *lepida* and *cuneata*, and I rather expect that it will become necessary to regard the latter as a subspecies of *lepida*. At the same time, numerous eastern specimens of *cuneata* show no intergradation with *lepida*. It is perhaps a case like that of the bird-genus *Colaptes*.

Nomada (**Gnathias**) **albofasciata,** Smith.

Two ♂s (sent by Prof. Gillette); one Fort Collins, foothills, April 24, 1900, by Titus; the others "Colo. 1581" taken at Fort Collins, foothills, May 6, 1904, by C. F. Baker.

Nomada (**Gnathias**) **bella,** Cresson.

A Colorado ♀ without locality label (sent by Prof. Gillette).

Nomada (**Gnathias**) **rubrella,** new species.

♂; length hardly 7 mm.; closely allied to *N. schwarzi*, but differing as follows: Smaller; light markings creamy-white instead of yellow; sides of front narrowly, sides of vertex broadly (and enclosing a yellow spot), a band behind ocelli, and posterior orbital margins ferruginous; mesothorax dark ferruginous with a median black stripe; most of pleura ferruginous; metathorax (all black in *schwarzi*) ferruginous with an elongate black mark; middle femora with a little more than the basal third black behind, the black very sharply defined from the red; tegulæ smaller and yellower; first abdominal segment (black right across at base in *schwarzi*) with very little black, only forming lateral hook-shaped marks; apical portion of abdomen not blackish; apical plate much less strongly notched. In both there is a yellowish mark at the apex of the abdomen beneath.

Habitat. Fort Collins, Colorado, May 18, 1901, near foothills, taken by Mrs. Laura Titus from plum blossoms.

Nomada (**Nomadula**) **americana** variety **dacotana,** Cockerell.

♂, ♀ (sent by Prof. Gillette); the ♂s are not distinguishable from true *americana*. Fort Collins, Colorado, May 28 and June

17. Also Colorado 2562 (Fort Collins, June 11, 1893, C. P. Gillette, collector), 1170 (Fort Collins, June 13, 1893, C. P. Gillette, collector) and 623 (Fort Collins, July 5, 1903, C. P. Gillette, collector).

Nomada (Nomadula) martinella, Cockerell.

Three ♀s (sent by Prof. Gillette) are variable, and do not support the idea that the Colorado form is distinct from that of New Mexico. Two are from Fort Collins, May 28 and June 19; the other is marked Colorado 2521 (Fort Collins, May 28, 1897, E. S. G. Titus, collector).

The ♂ of *N. martinella* has not been described, but I find three specimens in the Colorado collection. They are closely allied to *N. scita*, but are readily separated by the broader abdomen and darker legs; the tegulæ are bright lemon yellow with a hyaline spot; the thorax is covered with coarse hair which has a decided brownish tint. The scape is more swollen than in *scita*, and the yellow of the face is darker and stronger. The hind femora are stout with the lower edge decidedly concave. The scutellum is black. These ♂s are marked Fort Collins, May 20 and 21, and Colorado 2521.

Nomada (Micronomada) vegana, (Cockerell).

This was described as a variety of *N. modesta*, but it seems to be a distinct though closely allied species. The ♂s are like true *modesta*, but uniformly small. Prof. Gillette sends five ♂s and two ♀s. They are mostly from Fort Collins, July 4 to 20; one is marked Colorado 1204 (Fort Collins, June 26, 1893, attracted to Helianthus leaves by their secretions.—C. F. Baker, collector).

Nomada (Micronomada) vegana variety **nitescens,** new variety.

♀, just like *vegana*, except that the mesothorax, instead of being very closely punctured, has large irregularly scattered punctures on a shining ground. The ground-color of the first abdominal segment is red, and there is a red supraclypeal mark. Perhaps a distinct species.

Fort Collins, Colorado, August 8, 1899 (E. S. G. Titus, collector).

Nomada (Micronomada) lamarensis, new species.

♂, length about 9½ mm.; red, yellow and black. Markings bright lemon yellow, the pattern as in *N. vegana*, except that the mark on the pleura is narrower, the marks on the metathorax are wholly absent, and the band on the second abdominal segment is extremely broad; the ground-color of the body is dark red, becoming black on the vertex, the anterior part of mesothorax, and the enclosure of metathorax, and almost black on the pleura below the yellow band; the fourth abdominal segment is black anteriorly to the rather narrow yellow band, and the fourth ventral segment is black with two transverse reddish stripes, one on each side. The insect is much more robust than *vegana* (in build similar to *wheeleri*), and the head and thorax are very coarsely punctured; the punctures of the mesothorax are extremely large, and many of them confluent. Those of the pleura also very large. Sides of vertex with the

punctures very irregular, but leaving a good deal of shining surface; antennæ red, third joint longer than fourth, flagellum blackish above; tegulæ yellow with a ferruginous spot and rim; wings dusky, the apex very dark; stigma orange-ferruginous; nervures fuscous; second submarginal cell large and nearly square, receiving the recurrent nervure just beyond the middle; basal nervure meeting transverse-medial; ventral surface of abdomen without yellow markings; legs red, hind coxæ with a yellow spot, hind tibiæ with some yellow; anterior coxæ with red spines. Apical plate deeply notched.

One from Lamar, Colorado, June 17, 1900, (E. D. Ball, collector). This cannot be the ♂ of *N. wheeleri*, as that species has the submarginal cells quite different; in *wheeleri* the third submarginal cell is at least as broad above as the second, in *lamarensis* the second is rather more than twice as broad above as the third. The wings are much darker in *lamarensis* that in *wheeleri*. *N. lamarensis* resembles *N. crassula* in the very coarsely punctured mesothorax, and also in build, but differs in its red color, more strongly (indeed very strongly) bilobed scutellum, presence of a supraclypeal mark, etc.

Nomada (Micronomada) uhleri, new species.

♂; length about 7½ mm.; similar to *N. vegana* but more robust, the abdomen of spherical form, after the manner of *N. erigeronis*; markings light primrose-yellow (deep yellow in *vegana*), similar to those of *vegana*, but the labrum is entirely light red, the scape has only a yellow shade, and the metathorax is wholly without yellow marks; the mesothorax is densely punctured, more densely and coarsely than in *vegana*; ground-color of head and thorax black, but middle of mandibles red, a small red spot beneath the wings, and a red patch above middle and hind coxæ; antennæ red, scape and basal part of flagellum blackened above, the black not ending abruptly; tegulæ primrose-yellow, with hyaline spot and margins; wings clear, with very dark apex; stigma ferruginous, nervures piceous, second marginal cell nearly square, and receiving the recurrent nervure very near the middle; in one wing of the type the first recurrent nervure is divided at the end, forming an areolet under the second submarginal cell; basal nervure meeting transverse-medial, and third antennal joint longer than fourth, as usual in *Micronomada*; spines on anterior coxæ red and very long; legs red, anterior tibiæ with a light yellow stripe in front, hind coxæ with a yellow mark; there is a yellowish spot at the apex of each femur. and at the end of the hind tibia; abdomen dark brown above, clear red on first segment, beneath dark ferruginous, with linear yellowish markings; above, the first segment shows a broad primrose-yellow band, the second an extremely broad band, narrower in the middle, and the others bands which are hidden by the retraction of the segments; apical plate strongly notched.

One from Fort Collins, Colorado, August 18, 1900, (E. S. G. Titus, collector). Named after Dr. Uhler, who was one of the first to collect species of *Nomada* in Colorado.

Nomada (Holonomada) grandis, Cresson.

One marked Colorado 2509, taken in the foothills near Fort Collins, May 26, by C. P. Gillette. This differs from *N. magnifica* in the venation, but otherwise they are practically the same. I do not know whether the differential character, which in the case of *Gnathias* is certainly subgeneric, can here be only varietal.

Nomada (Holonomada) pecosensis, (Cockerell).

A ♂ from Palisades, Colorado, May 7, 1901, from apple bloom, (C. P. Gillette collector). It differs from the ♀ in having the pleura with a comparatively small yellow mark, and no yellow spot in front of anterior ocellus; the abdomen also is more inclined to be punctured. The species is the Rocky Mountain representative of *N. edwardsii*, from which it is easily known by the red color on the legs. Except as to the abdomen, the ♂ *N. pecosensis* agrees with the description of *N. intercepta*, Smith, from Vancouver I., which is evidently a *Holonomada*.

Nomada (Holonomada) vincta, Say.

Perfectly genuine *vincta*, one of each sex, were taken by F. C. Bishopp, at Fort Collins, Colorado, September 4 and 12, 1903, from sunflowers. (Helianthus sp.)

Nomada (Holonomada) zebrata, Cresson.

A ♀ collected by E. S. G. Titus at Fort Collins, July 28, 1900. When we consider *N. zebrata*, *vincta*, *morrisoni*, etc., the distinctions between *Holonomada* and *Xanthidium* appear to completely break down. *Holonomada* might possibly be restricted to *superba*, *edwardsii*, *pecosensis*, and their immediate allies; if this is not done, *Xanthidium* must I think be given up.

Nomada civilis, Cresson.

Three ♂s; Fort Collins, May 12, 1901, from plum blossoms, (E. S. G. Titus, collector) and one Denver, May 2, 1902.

Nomada (Xanthidium) rhodoxantha, new species.

♀; length about 10 mm., head and thorax ferruginous, strongly and closely punctured; scutellum prominent, bilobed; antennæ long, entirely red, third joint much shorter than fourth, flagellum stout; labrum with a minute denticle; extreme lower corners of face yellow, but no yellow on clypeus or mandibles; upper border of prothorax with a yellow stripe; tubercles and tegulæ ferruginous, the latter strongly punctured; pleura with an obscure yellow spot posteriorly; metathorax with a median black band, on each side of which is a large area (including the sides of the enclosure) variegated with red and yellow; legs red, middle femora at base beneath, and hind femora largely blackish; wings clear with a brownish stain along the nervures, tips dusky; stigma bright ferruginous, nervures brown; second submarginal cell broad above, third greatly narrowed above, its outer margin strongly angled; basal nervure a short distance basad of transverse medial; abdomen minutely rugulose, ferruginous, with broad entire yellow bands on all the segments, basal half of first segment black; venter ferruginous, marked with yellow. The mesothorax has a strongly marked median black band.

One specimen, Colorado, without other locality label.

This has the general appearance of *N. morrisoni*, *luteoloides*, etc. From *luteoloides* it is easily known by the ferruginous, densely punctured (minutely cancellate) scutellum. From *morrisoni* it differs by the much narrower mesothorax, with larger and much more distinct punctures; the shape of the third submarginal cell, etc. From *placitensis* it differs by the much longer fourth antennal joint, the absence of the conspicuous brown hair on vertex and dorsum of thorax, etc. A form of

N. rhodoxantha differing in some slight details of color, has been taken by Dr. Graenicher at Milwaukee, Wisconsin, on June 3.

Nomada (Xanthidium) crawfordi, new species.

♀; length about 11 mm., another red species with entire and broad bright yellow bands on the abdomen, similar to the last, but the first segment has a round yellow spot on each side, instead of a band. The sides of the face broadly, the anterior edge of the clypeus, the labrum, the upper margin of prothorax, the tubercles, two spots on the tegulæ, and four spots on the metathorax, are yellow. The ventral surface of the abdomen is mainly yellow beyond the first segment. The scape is suffused with yellow in front, the flagellum is strongly blackish above towards the end, but the extreme tip is red; the third antennal joint is a little shorter than the fourth; the second submarginal cell is broad above, the third much narrowed above, its outer margin strongly angled; the basal nervure is a short distance basad of the transverso-medial.

It is distinguished from the various similar species thus:

From *N. dilucida* by the mesothorax being entirely red except the narrow anterior border and the median band, which are black; by the scutellum being entirely red; by the metathorax having four yellow spots; by the strongly punctured tegulæ; by the hind femora having a long-oval red mark clean-cut out of the blackish at the base behind; by the hind tibiæ being entirely red, but the basal joint of the hind tarsi yellow behind; and by the first abdominal segment being red, with a yellow spot on each side between two black spots. From *N. rhodoxantha* by the broader form, longer third antennal joint, duskier wings, and quite different pattern of first abdominal segment. From *N. morrisoni* by the longer fourth antennal joint, peculiar color of flagellum, red scutellum, shape of third submarginal cell, etc. From *N. placitensis* by its larger size, yellow on face, much less black on thorax, etc. From *N. zebrata* by the proportions of the antennal joints, red scutellum, etc. From *N. citrina* v. *rufula* by the red pleura and scutellum, the color of the flagellum, the absence of a yellow spot at the apex of the posterior femora, etc. The yellow of the legs is practically confined to the hind tarsi and front knees.

One specimen; Virginia Dale, Colorado, June 20, 1901, F. C. Bishopp, collector. *N. crawfordi* is named after Mr. J. C. Crawford, Jr., in recognition of his work on bees.

Nomada (Xanthidium) collinsiana, new species.

Two ♀s taken by S. A. Johnson, Fort Collins, Colorado, May 11 and 20, 1903. One from wild plum. I had at first considered this a variety of *N. crawfordi*, but it may be kept separate for the present, at any rate. It differs from *crawfordi* thus: A trifle smaller; no yellow whatever on head or thorax; middle of front black, with a red spot in front of anterior ocellus; flagellum red; apical part not blackened; thorax more hairy; tegulæ entirely red; third submarginal cell nearly or not far from as broad above as second; basal nervure more basad of transverso-medial; legs without yellow, except a small obscure spot at base of anterior and middle tibiæ; hind femora red, with a broad black stripe behind, not reaching either end, and on it a band of short yellowish hair; hind coxæ with much black (only a little in *crawfordi*); base and apical margin of first abdominal segment black; pygidial plate narrower, venter ferruginous marked with yellow and black.

Nomada (Xanthidium) perivincta, new species.

A ♀ marked Colorado, without definite locality.

Length 10½ mm.; ground-color of head and thorax black; labrum yellow, with a small reddish spine; mandibles pale ferruginous, with black tips; face below antennæ yellow; the upper part of clypeus, and upper part of supraclypeal area, ferruginous; front with ferruginous bands continued from the lateral face marks, strongly curving inwards; a red spot before middle ocellus; posterior orbital margins rather broadly red; scape ferruginous behind, bright yellow in front; flagellum ferruginous, the last six joints strongly blackened, the extreme apex red; fourth antennal joint much longer than third; mesothorax very coarsely and densely rugoso-punctate, its lateral margins yellow edged with ferruginous; upper border of prothorax, tubercles, scutellum, a spot at each anterior corner, postscutellum, and large quadrate marks on metathorax encroaching on enclosure, all bright yellow; pleura yellow, with a small black and red mark above, and a large black mark surrounded by red below; legs a lively red; hind coxæ with a large black mark behind and a yellow one above; anterior femora yellow in front and apically, middle fomora with less yellow in front, but a large mark at apex, hind femora with a yellow stripe in front and a large black area behind; tibiæ yellow on outer side, hind tibiæ with a black stripe behind; basal joint of hind tarsi mainly yellow; tegulæ shining and sparsely punctured, ferruginous with a yellow spot in front; wings rather yellowish, apex clouded; stigma bright ferruginous, nervures brown; second submarginal cell very broad above, not far from square, receiving the recurrent nervure well beyond its middle; third a little broader below than second,but very greatly narrowed above, its outer margin strongly angled;basal nervure meeting transverso-medial; abdomen minutely rugulose, bright yellow, with the base of first segment, and three broad bands at the junction of the segments, black; hind margin of fourth segment reddish brown, fifth all yellow; venter yellow (reddish on sides of first segment) with three black bands on which are reddish stripes.

N. perivincta differs from *N. vincta* by the considerably larger punctures of the mesothorax, the color of the hind legs, the yellow of metathorax intruding on enclosure, the proportions of the antennal joints, etc. From *N. citrina* it differs by the narrower face, the broad third submarginal cell, etc. From *N. citrina* v. *rufula* by the narrower face, the blackened apical part of flagellum, etc. From *N. rhodoxantha* by the yellow scutellum, color of legs, etc. From *N. sulphurata* by the much narrower first segment of abdomen, broad third submarginal cell, etc. From *N. rivalis* by the markings of thorax and legs, etc.

Nomada perivincta variety **semirufula,** new variety.

A ♀ marked Colorado, without definite locality.

Mesothorax mainly dark red,with a broad median black band, and a good deal of black on the anterior and posterior margins; anterior lateral corners only yellow. Lower part of pleura with a large red patch without black; yellow marks on metathorax margined with red; first abdominal segment considerably broader, its basal half red with a blackish transverse band; venter with black bands only on the first and extreme base of fourth segments. This resembles *N. sulphurata* in the darkened apical part of flagellum, etc., but the first abdominal segment though broader than in the type, is by no means so broad as in *sulphurata*, while the colors of the mesothorax and ventral surface of abdomen, and the shape of the third submarginal cell, are quite different. The basal nervure in

semirufula begins well basad of the transverso-medial, as in *sulphurata* and not as in *perivincta*.

Nomada gillettei, new species.

Named after Professor Gillette, who has done so much for Colorado entomology. The type is a ♂ marked Colorado 2198. Taken at Golden, July 3rd, by C. P. Gillette.

Length 9½ mm.; head and thorax black, densely and coarsely punctured; facial quadrangle considerably broader than long; front concave; labrum, basal half of mandibles, clypeus, very broad lateral face marks ending at level of antennæ, and broad marks beneath eyes, all chrome yellow; antennæ lively ferruginous, fourth joint much longer than third; scape quite swollen, yellow in front, and with a black dash and dot behind; hair of head and thorax scanty, white; upper border of prothorax, tubercles, V-shaped mark beneath, and a spot on each side of the lower part of metathorax, all yellow; scutellum with two minute red spots; legs a lively red, extreme base of anterior and middle tibiæ with an obscure yellowish spot; middle femora with a small black spot at extreme base; hind femora nearly all black behind; tegulæ punctured, whitish tinged with red; wings clear, yellowish along the nervures; stigma and nervures ferruginous; second submarginal cell broad above, receiving the recurrent nervure a little beyond its middle; third at least as broad as second below, but narrowed more than half above, its outer margin bent; basal nervure a short distance basad of transverso-medial; abdomen yellow, the bases of the segments black, their apical margins pale ferruginous; the yellow band on the first segment is interrupted in the middle by a reddish triangle pointing posteriorly; apical plate narrow, feebly notched; venter yellow, banded with dark reddish brown. The face is bare, without the beautiful appressed white hair seen in *N. elrodi*. The colors of the abdomen recall *N. civilis*.

Nomada agynia, new species.

One ♂ sent by Prof. Gillette, marked Colorado 2196, Golden, July, C. P. Gillette, collector.

Length about 9 mm.; black with yellow markings; head broad, facial quadrangle about square; basal two-thirds of mandibles, labrum, clypeus, lateral face-marks (broad below, gradually narrowing to a point at top of eyes) and posterior orbits nearly to summit, all yellow; clypeus with the usual sutural black spots; supraclypeal mark obscure reddish, narrowly surrounded by black; antennæ not very long, third joint much shorter than fourth; scape stout, heavily marked with black on a red field above, yellow below (in front); flagellum dark ferruginous, blackish above, especially towards base; mesothorax dull, very densely and quite coarsely rugoso-punctate, the anterior lateral corners, and a few marks on lateral margin, red; upper border of prothorax, tubercles, scutellum and postscutellum, yellow; pleura red with a broad curved transverse yellow band, and a large black spot beneath; metathorax black in the middle, the sides (encroaching on the enclosure) variegated with red and yellow; tegulæ yellow, large, shining and rather sparsely punctured; wings quite long, hyaline, the apex blackened; stigma ferruginous, nervures fuscous; second submarginal cell broad below, but narrowed above; third broad below, and narrowed more than half above; basal nervure a short distance basad of transverso-medial; legs lively ferruginous, the hind femora and tibiæ darker, the hind femora black behind except at base and apex; middle femora somewhat swollen, with a blackish spot on apical half behind; knees, and a stripe on anterior tibiæ, yellow; abdomen rather broad, closely and minutely punctured; all the segments yellow with black bases and ferruginous apical margins, the yellow of the

first segment with a pair of small reddish sublateral marks; apical plate narrow, truncate, with the faintest suggestion of an emargination; venter yellow with blackish and reddish bands.

This is possibly the ♂ of some described species, but after repeated comparisons, I cannot satisfactorily assign it to any. In my table in Proc. Acad. Nat. Sci. Phila., 1903, p. 559, it runs to *pascoensis*, which it superficially resembles, but it is easily known from that by the quite ordinary last antennal joint, the light marks on metathorax, etc.

Nomada pallidella, new species.

One ♂ marked Colorado 566 (Montrose, June 24, 1902, C. P Gillette, collector).

Length about 7½ mm.; black, marked with pale yellow; quite hairy. Facial quadrangle about square: labrum, mandibles except tips, narrow stripe beneath eyes, clypeus and lateral face-marks, yellow,lateral face-marks reduced to a triangle at lower corners of face, which sends a line upwards along orbital margin nearly to level of antennæ; antennæ long, scape ordinary, yellow in front; third joint much shorter than fourth; flagellum dark ferruginous, blackened above; mesothorax dull and very densely rugoso-punctate; tubercles, a small mark on anterior part of pleura, and two spots on scutellum, yellow or yellowish tinged with reddish; metathorax entirely black; hair of dorsum of thorax brownish; tegulæ ferruginous, punctured; wings iridescent, dusky at tips; stigma ferruginous, nervures fuscous; second submarginal cell broad above, third greatly narrowed above; basal nervure meeting transverso-medial, but a little on the basad side: legs red without any yellow; basal half of anterior femora behind, most of basal two-thirds of middle femora behind and beneath, and all of the hind femora except apex, black; hind tibiæ with a blackish dash on inner side; abdomen minutely roughened; light yellow bands on segments two to six not interrupted, but those on four and five enclosing laterally a dark spot; band on first segment with a rather broad median ferruginous interruption, the area posterior to the band also being ferruginous, with two blackish dots; otherwise, the dark parts of the abdomen are black or almost so; apex with long hairs; apical plate quite broad, deeply notched; venter red-brown, with yellow bands bent in the middle and not reaching the lateral margins.

From Robertson's *N. salicis* and *N. simplex* (♂s) this is readily separated as follows:

Apex of abdomen strongly notched.............................. 1.
Apex of abdomen slightly notched; scutellum black......*simplex*.
1. Legs marked with yellow ....*salicis*.
Legs not marked with yellow................... .... *pallidella*.

The Californian *N. subangusta*, Ckll., is very near to *N. pallidella*, but it has the first abdominal segment narrower; the abdomen, where not yellow, mainly red; the scutellum entirely black, the second submarginal cell narrower; and the red of the flagellum much brighter. In the face-marks, hairy thorax, etc., they agree.

From *N. modocorum*, Ckll., *N. pallidella* is easily known by the much narrower, parallel-sided abdomen, with much paler markings, those of *modocorum* being bright yellow.

Nomada sayi, Robertson.

One ♀ collected by E. S. G. Titus at Virginia Dale, Colorado, July 24, 1899, from wild geranium. The date seems too late for *sayi*, and the specimen is hardly typical; it is not *N. lehighensis*, which flies in July. Probably when we have a good series of the Colorado insect, including both sexes, it will be possible to separate it subspecifically, at least.

Nomada coloradella, new species.

A pair; ♂, Fort Collins, Colorado, June 18, 1900; ♀, Colorado 633 (Dolores, June 18, '92, C. P. Gillette, collector).

♂; length 5¼ mm.; head and thorax black, with abundant white hair; labrum, mandibles except tips, clypeus and lateral face-marks, bright yellow; lateral face-marks consisting of triangles occupying the lower corners of face, sending a line upwards to level of antennæ; facial quadrangle somewhat broader than long; antennæ very long; scape moderately stout, yellow in front and black behind; third joint much shorter than fourth; flagellum submoniliform, pointed at apex, bright light yellowish-ferruginous, the first four joints black above; tubercles and tegulæ reddish-testaceous, scutellum with two reddish spots, thorax otherwise all black; wings clear, dusky at apex; nervures and stigma yellowish-ferruginous, marginal cell long; second submarginal broad above, receiving the recurrent nervure far beyond its middle; third submarginal very broad below, greatly narrowed above, its outer margin strongly bent; basal nervure meeting transverso-medial (in *N. sayi* it is a long distance basad of it); legs red, the femora blackened behind and beneath; abdomen ferruginous, basal half of first segment black; a bright yellow band, interrupted in the middle, on segments 2 and 3; yellow hardly apparent on 4, but prominent on 5 and 6; apex with long hairs; apical plate moderately notched; venter ferruginous.

♀; length about 6 mm., red, mesothorax and metathorax each with a single black band; ocelli on a black patch, but front all red; antennæ red, scape with a blackish apical spot on inner side; third antennal joint about as long as fourth; first segment of abdomen practically without black; basal nervure meeting transverso-medial, but on the basad side. The ♂ is to be regarded as the type; it is not quite certain that the ♀ belongs to it, but it is probable enough to justify the association for the present. The ♂, in its color and markings, is like *N. sayi*, but it is easily distinguished by the venation. It differs from *N. rhodosoma* by its smaller size and much lighter antennæ and stigma; from *N. oregonica* by its light orange stigma, and apical half of flagellum not black above; from *N. lehighensis* by its smaller size, and quite different color of antennæ and stigma; from *N. pygmæa* by the absence of supraclypeal mark, and orbits not ferruginous. It is also allied to *N. illinoiensis*. The ♀ resembles *N. rhodosomella*, but is separatel by the characters given in the table.

Nomada luteopicta, new species.

Two ♂s and a ♀ collected by Prof. Gillette; all Palisades, Colorado, May 7, 1901, from apple blossoms.

♂; length about 6¼ mm.; head and thorax black, with abundant white hair; labrum, mandibles except tips, narrow stripe beneath eyes, clypeus and lateral face-marks (consisting of a triangle at lower corners of face, sending a line upwards to level of antennæ) all bright-yellow; eyes green; antennæ long, scape rather swollen, yellow in front and black behind; third joint shorter than fourth; fourth shorter than last; flagellum bright clear yellowish-ferruginous, the first four joints black above; tubercles, tegulæ, upper border of prothorax, mark on anterior part of pleura, and two clearly-defined oval spots on scutellum, yellow; wings slightly dusky, apex darker; stigma dark ferruginous, nervures fuscous; second submarginal cell very narrow, or broadened below by the lengthening of the lower basad corner, in which case the recurrent nervure is received much beyond its middle; third submarginal extremely broad below, narrowed more than half above, its outer side strongly bent; basal nervure meeting transverso-medial; legs red, middle and hind coxæ mainly black; middle femora with a black stripe beneath, hind femora mostly black behind; all the knees broadly, and apex of hind tibiæ, yellow; abdomen yellow, the segments ferruginous on apical margin, and more or less black basally; apex with long hairs, apical plate very feebly notched;

venter yellow, ferruginous at base, and with the hind margins of the segments broadly pale ferruginous.

♀; red; mesothorax and metathorax with a median black band; third antennal joint not greatly shorter than fourth; abdomen red, not black at base; second and third segments with a subquadrate bright yellow spot on each side, third also with a pair of yellow dots mesad of the spots, fourth with a yellow band, not reaching lateral margins, fifth with a short broad band; venter without yellow.

The ♂ is to be considered the type. It is closely allied to *N. coloradella*, but larger, with a broader abdomen, with much more yellow. The ♀ is very near to *N. lewisi*, Ckll., but has no yellow at lower corners of face; and has the third submarginal cell much broader. The scutellum of the ♀ is low and scarcely bilobed, as in *N. simplex*, Rob., which is closely allied; but *simplex* has much more black on the head and thorax, and the fourth abdominal segment spotted instead of banded.

Nomada coloradensis, Cockerell.

A pair; the ♂ marked Fort Collins, Colorado, foothills, May 19, 1900, E. S. G. Titus, collector: the ♀ marked Colorado 566, just like the original type. Taken June 24, 1892, at Montrose, by C. P. Gillette. At Milwaukee, Wisconsin, Dr. Graenicher has taken a form of *N. coloradensis*, which may prove to be subspecifically separable.

The ♂ has not been described. It is very similar to several ♂s, from which it is readily separated as follows:

Scape conspicuously swollen, apical plate broad ....1.
Scape ordinary; venter red not spotted with yellow; apical plate narrow ....3.
1. Pleura with much red; metathorax with four red spots; venter with large yellow markings............*bethunei* Ckll.
Pleura and metathorax without red (or pleura with a small red mark)....................2.
2. Venter spotted or banded with yellow........*vicinalis* Cresson.
Venter red without yellow. ....*vicinalis* var. *infrarubens* Ckll.
3. Larger; mesothorax marked with red; first abdominal segment with a yellow band ....*armatella* Ckll.
Smaller; metathorax all black; first abdominal segment without a yellow band ....*coloradensis* Ckll.

I am greatly indebted to Mr Rehn for the information that Cresson's type of *N. vicinalis* has the apical plate of abdomen broad, scape normal, base of metathorax more granulose than rugulose, labrum with a very slight median denticle.

N. vicinalis infrarubens is a new variety obtained by Prof. Cordley at Corvallis, Oregon, June 6, 1899. It has the following noteworthy characters; labrum very hairy; ends of linear upward prolongation of lateral face-marks slightly bending from orbits; flagellum bright red, the last joint pointed, the first five joints black above; hair of upper part of thorax (especially scutellum) strongly brownish; tubercles reddish with a yellow spot; tegulæ, scutellum, two stripes on mesothorax, and a small mark on lower part of pleura in front, red; first abdominal segment with basal half black, with two red marks; yellow bands on segments 1 to 5 broadly interrupted by red in the middle; sixth segment with a short bilobed yellow band; apical plate very hairy. The antennæ remind one of *N. pascoensis*, but the insect is otherwise very different.

Nomada alpha, new species.

One ♀ taken by F. C. Bishopp, marked Fort Collins, May 20, 1903, Colorado. Taken from flowers of *Capsella bursa-pastoris*.

Length about 8½ mm.; head and thorax red, with black and yellow markings; abdomen red and yellow. Front depressed, coarsely and

closely punctured; facial quadrangle much broader than long; mandibles very shiny, pale reddish with black tips and more or less yellow bases; labrum, clypeus, and sides of face on each side of clypeus, yellow, the yellow not sharply defined from the red just above; ocelli on a black patch, connected with a black patch on front, but leaving a red mark in front of middle ocellus; frontal patch sending black bands to sides of clypeus, these and the narrowly blackened upper clypeal suture making a large A; posterior orbital margins very broadly red, with a large yellow stripe on the lower two-thirds; antennæ long, red without any black, scape yellowish in front; third joint longer than fourth; mesothorax coarsely rugoso-punctate, red with three rather ill-defined black stripes; prothorax black, with its upper border, and the tubercles, yellow; pleura red, with a black spot beneath; a broad black band from wings to middle and hind coxæ; scutullum red suffused with yellow; postscutellum bright yellow; metathorax black, with a large red spot on each side; tegulæ red; wings yellowish, apical margin not much darker than the rest; stigma bright orange-ferruginous, nervures pale brownish; second submarginal cell moderately narrowed above; third of the narrow type; basal nervure a long distance basad of transverso-medial; legs bright red, anterior and middle femora with more or less of a yellow apical spot; hind femora wholly without black; abdomen very minutely rugoso-punctate; first segment red with a transverse yellow mark on each side; second red with very large pyriform yellow marks; third similar, but with even more yellow; fourth yellow except extreme base and apical margin: fifth yellow; venter banded with yellow and red.

In Robertson's tables this runs to *Holonomada*, but it is closely related to some of the species which are referred to *Xanthidium*.

Nomada libata, Cresson.

This is erroneously called *limbata* in Dalla Torre's Catalogue. Mr. Rehn has kindly examined Cresson's type ♂, and finds the apical plate rather narrow, deeply notched; the ventral surface of abdomen immaculate except the apical margins of the three terminal segments, which are yellow to a considerable degree; scape normal.

These characters are in part similar to those of *N. armatella*, which may be known from *libata* by the absence of yellow on venter and the basal nervure far basad of transverso-medial (in *N. libata*, *parata*, *bethunei* and *coloradensis* it is only a little basad of it).

Nomada dilucida, Cresson.

Mr. Rehn has kindly examined Cresson's type ♀, and finds it differs structurally from *N. morrisoni* thus: labrum narrower, more rectangular; scape heavier and more robust; abdomen glabrous instead of pubescent.

I am extremely indebted to Mr. Viereck, who has most kindly examined all of the types in the collection at Philadelphia, and reported on the venation and proportions of the third and fourth antennal joints.

Nomada frieseana, Cockerell and **N. semiscita,** Cockerell.

These two species were discovered at Colorado Springs since this paper was written, and described in Annals & Mag. of Nat. Hist., July 1904. *N. frieseana* is allied to *N. rubicunda*, and *N. semiscita* to *N. scitiformis*.

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EARLY CANTALOUPES.

—BY—

P. K. BLINN.

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EARLY CANTALOUPES.

BY P. K. BLINN.

One of the most important questions connected with cantaloupe growing is how to get them early, for here as elsewhere it is the "early bird that catches the worm." The high prices received for the first cantaloupes on the market offer great reward to the grower who is successful in maturing his crop a few days in advance of his neighbors.

It is not uncommon in the vicinity of Rocky Ford for the extra early cantaloupe field to return to the grower from two to three hundred dollars per acre, and it is in hope of such returns that every grower plants his seed; but as the season advances it soon becomes evident that from one cause or another many have fallen behind in the race, and only those who are fortunate enough to escape the various adverse conditions which beset the crop from time to time and check its growth, succeed in getting the early crates.

Some of the many factors that influence the development of a crop of cantaloupes are beyond the control of the farmer, but this bulletin is planned to deal with the elements that can be influenced by him, not with a view to giving specific rules which will insure an early crop, for the varied conditions of different farms and seasons make explicit directions of little value; but to present from observation and experience such facts as may reveal to some extent the underlying principles to be considered in producing a crop of cantaloupes.

Seed.—The Netted Gem cantaloupe is virtually the only variety grown in the cantaloupe growing sections of Colorado, yet there is almost a variety variation in some of the strains of seed from different growers, due to varying lines of selection. It is generally conceded that the most perfectly developed types are not quite so apt to be early as the cantaloupe grown from "slickers" or culls; but the ultimate value of a good melon and its influence on the market make it imperative for the grower to plant nothing but the best seed, of ideal type and quality, with early tendencies. It is evident from numerous comparative observations that the question of seed does not have so much influence in producing

early cantaloupes as does the care and cultivation in handling the crop.

Soil.—Experience has proven that a sandy loam is the soil best suited for cantaloupes, and that its condition of tilth and the available fertility are the prime essentials in bringing cantaloupes to quick maturity.

The secret of getting soil in that ashy, mellow condition so desirable for cantaloupes is largely one of experience, for hardly two farms can be handled the same. In general, there must be moisture in the soil over winter to get the disintegrating effect of frost, and plowing should not be done until the ground is dry enough to pulverize mellow. Barnyard manure has long been the means of supplying fertility to force cantaloupes to early maturity; but owing to the limit of its supply, crop rotation became necessary, and in 1896 the Sub-Experiment Station at Rocky Ford made the first test of cantaloupes on alfalfa sod, which resulted in signal success, demonstrating that alfalfa sod affords ideal soil conditions for cantaloupes both in early production and in securing a big yield. The test was on a plat of one acre, which was planted May 4th in hills six feet each way and received ordinary care; the plat having three hoeings, four cultivations and seven irrigations during the season. The first crate of ripe cantaloupes was marketed July 29th, only one day later than the earliest record ever made at Rocky Ford with cantaloupes on well manured ground. The vines made a remarkably uniform growth and the yield was three hundred and fifty standard crates per acre, nearly double the normal yield on ordinary soil. Since then alfalfa sod has been in general nse for cantaloupes in the crop rotations of the Arkansas Valley.

Its relative value over old, worn-out land is well contrasted in Plate 1, which is a photo taken July 7th on the farm of I. D. Hale; the rows on the right were planted on alfalfa sod at the same time and had the same care as the balance of the field.

The same contrast is often seen in land that has been growing beets and that which has not, the beet ground being unfavorable for early cantaloupes; indeed, experience of four years at Rocky Ford since the introduction of the beet crop testifies that it is useless to expect early cantaloupes on beet ground, although if the land is not too much exhausted, very satisfactory late cantaloupes have been grown after beets.

During the season of 1904 several commercial fertilizers have been tried extensively to supply the needed elements for growing early cantaloupes on beet ground, but the results are so conflicting that a conclusion is not warranted, except that the use of the fertilizer in and under the hill at planting time is extremely hazardous.

PLATE 1.

PLATE 2. COLO. AG. EXP. STA.

PLATE I.—Cantaloupes at right grown after alfalfa. At left on worn out soil.

PLATE II.—Root System of Cantaloupe Seedlings.

PLATE 3.

PLATE 4. COLO. AG. EXP. STA.

PLATE III.—Showing Development of Cantaloupes. Photo taken July 2, 1904.

PLATE IV.—Same Field Two Weeks Later.

Hardly a grower who used the special melon fertilizers according to directions, but lost from a few rows to many acres of early cantaloupes. The little melon plants died when the roots came in contact with the caustic elements of the fertilizer. A few growers had encouraging results; and when the manner of applying and the quantity to be used in relation to irrigated conditions is determined by careful experiments, the use of commercial fertilizers may result in valuable profits to the melon growers, but until then, barnyard manure and rotation with alfalfa and other liguminous crops offer the safest and most reliable source of fertility.

Care and Cultivation.—If there is a secret in getting early cantaloupes it is in growing the crop from start to finish with a uniform unchecked growth; the cantaloupe does not seem to have the power to rally from a check in growth or an injury from an insect and still make its normal development. The back-set not only cuts off the production of early cantaloupes but seriously affects the size and quality of the melon. There are numerous instances where unfavorable conditions of growth have produced a large quantity of pony melons, while under more favorably growing conditions the same seed and soil have yielded standard sized cantaloupes. One of the first signs of promise for early cantaloupes is a quick germination and rapid development of large cotyledons. Seed that germinates slowly with small yellow appearing seed leaves has never made early cantaloupes.

Planting.—The first requisite aside from moisture for a good start is warm weather, as cantaloupe seed cannot germinate when the ground is cold and freezing; and if perchance the days are warm enough to germinate the seed that is planted in March or April, the cold nights that are sure to follow will offset the advantage of early planting.

Fifteen years of weather records at the Sub-Station in Rocky Ford reveal the fact that in nine out of the fifteen years there has been frost the last few days of April or the first in May that seriously injured or completely killed any melons that were germinated at that time, and that light frosts and cold nights are common up to the middle of May. Old cantaloupe growers around Rocky Ford consider that May first is plenty early to plant cantaloupe seed.

The seedling period is the critical time in the development of a crop of cantaloupes. It is in that stage that it usually receives a check in growth from cold weather, high winds or lack of moisture. It is also at this time that the striped cucumber beetle makes its destructive attacks. A knowledge of the growth and root development of the seedling will in a measure help to explain the reason for the steps taken and the precaution necessary in handling the crop during this important period.

Plate 2 represents two cantaloupe seedlings, the one on the right revealing the plan of the first root system that develops when the seed germinates; it penetrates almost directly down from the seed while the stem is pushing its way to the surface. These roots seem to form a temporary support for the plant during the first two or three weeks, for up to that time the stem from the seed point up to the surface of the ground is smooth and white, with no evidence of the lateral roots which are shown on the stem of the seedling to the left. The second root system develops from the stem about the time the fifth leaf appears, or four or five weeks after germination; these roots seem to form the main feeders which develop the plant, for the growth of a hill of melons is practically insignificant until it feels the impulse of this larger and better root system. The question of early cantaloupes almost hinges on the success of the farmer in supplying conditions that will favor early development of the lateral root system.

It seems evident that the depth of planting and the manner of managing the soil in the hill has an important relation to the early development of these lateral roots. Experience teaches that seed planted much over two inches in depth are slow and difficult to germinate, being weakened by the long stem that is necessary to reach the surface, and on the other hand if planting is too shallow, the seed are apt to dry out, or if rain follows a crust will form which must be removed, and that often exposes the seed with fatal results, or leaves the plant with too shallow a stem support. It is then whipped and wrung by the high, dry winds, or the long stem is exposed to the attacks of the cucumber beetle.

Seed will germinate readily when weather conditions are favorable, if planted at about the depth indicated by the white portion of the stem of the seedling at the left in Plate 2. When the seed leaves are nearly to the surface, if a garden rake is drawn through the hills with a lifting motion it will remove any crust or dry lumps which obstruct the little melon plants.

Plenty of seed should be used to provide against loss in handling the hills or from attacks by insects; it also affords a chance to select the thriftiest specimens when the thinning is made to two or three plants. Owing to the injuries from the striped cucumber beetle, this thinning should not be done until the plant gets several leaves and the lateral roots are developed; the extra plants in the hill should be destroyed by pinching or cutting the stem, as pulling is apt to disturb the remaining plants.

The best known precautions against the cucumber beetle consists in the application of lime, ashes or road dust, and the continual working of the field with hoe or cultivator.

Hoeing.—Hoeing the hills is of great importance, but it should be done with skill both as to the time and the way it is

done, for careless hoeing is a common error; if the seed has been properly planted in mellow soil and the irrigation properly applied, there is no reason for deep hoeing in and close to the hill, as it only disturbs the plants and dries out the soil; weeds can be destroyed by shallow hoeing.

The dry, cloddy soil on the surface should be removed from the hill by hand and replaced with fine, moist, mellow soil, hilling up the plants as far as possible, which will protect the plants from wind and insects in a large measure; but the most important feature of this process is the holding of the moisture well upon the neck or stem and affording the best conditions for a long base and an early growth of the main root system. If, on the other hand, the soil in the hill is loosened up with the hoe and only hilled up by drawing the loosened soil to the plant with the hoe, the hill will usually dry out, and only a short portion of the stem be in moist soil, consequently it has but a short base for the production of its root system.

Cultivation.—A thorough preparation of the soil before it is planted to cantaloupes will very much lessen the necessity for so much cultivating afterwards, but a great deal depends on frequent and thorough cultivation during the early stages in the growth of cantaloupes; at first it should be deep and thorough, but not close enough to disturb the plants; the cultivations should be more shallow and further from the hills as the plants develop. The grower who cultivates deep and close to the hill because the vines do not prevent him, is cutting off one source of early cantaloupes. He should study the growth of the roots, for they form the counterpart of the vines on the surface, only they ramify the soil more thoroughly and to a greater distance than the length of the vines. Plates 3 and 4 will give a conception of the root system which must exist to produce such an increase of growth in so short a time; the first was taken July 2, 1904, and represents the growth of about eight weeks, while the second was taken at the same point two weeks later.

Irrigation.—Moisture for the cantaloupe hill is generally supplied by the irrigation furrow. It should always reach the seed or plant by soaking through the soil. Irrigation should never be allowed to over-soak or flood the ground, as the soil will then become hard and not permit a good growth.

The relation of irrigation to an early set of cantaloupes is a somewhat mooted question. There are growers who argue the use of frequent irrigations during the setting period to secure a good set, and there are others who prefer to keep the vines rather dry and even letting them show the need of water before they will irrigate during the setting stage.

There have been results that seemed to support both theories,

yet close observation would not warrant following either plan to an extreme, but rather a medium course of supplying enough moisture for an even, healthy growth, which seems to be the essential condition all the way through. An excess of irrigation during the hot weather in July will doubtless tend to grow vines at the expense of early fruit; but the most disastrous result of too much water—having the ground so soaked that the surface is nearly all wet, and affording the moist, dewey condition which is favorable to its development—is in the development of rust.

The rust problem is a serious one in cantaloupe culture in Colorado. Controlling it by proper application of irrigation is only a palliative measure, yet a marked contrast is often seen in two portions of a field; one over-irrigated, and the other comparatively dry, aside from the moisture necessary to the growth of the vines. Rainy weather and dewey nights afford the proper conditions for the growth of the rust spore, and while the farmer cannot change climatic conditions, yet by careful attention in the application of water, having the rows well ditched, and with adequate waste laterals to prevent over-soaking and flooding, the surface of the ground will dry rapidly after a rain or an irrigation. Thus the dews at night will be less, and in a measure alleviate the effects of rust.

Marketing.—The high prices which prevail at the beginning of the season, and the urgency of the commission men, have resulted in the shipment of many green and unmarketable melons. It is evident that a continuation of such practice will produce dissatisfied customers and consequently loss of trade. The popularity of the Rocky Ford cantaloupe and its value as a money making crop, should induce the farmers of the Arkansas Valley to maintain the standard of excellence by every means in their power, and to discountenance the shipping of green and otherwise unmarketable melons as an act of treachery to the cantaloupe industry.

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The Agricultural Experiment Station

FORT COLLINS, COLORADO.

Spraying for Plant Lice and the Codling Moth.

BY C. P. GILLETTE.

Plant lice have been extremely numerous on foliage of apple, cherry, plum and other fruit trees for two or three summers past. Many are inquiring what they should do to destroy these pests. In the fall of the year these lice lay minute black eggs upon the twigs of the trees and especially about the buds. To the unaided eye these eggs appear like fine grains of gunpowder. A few days before the buds open the young lice hatch from these eggs so that for a time they are exposed to treatment by means of insecticides. As soon as the buds open sufficiently, they work their way in among the expanding leaves and as the leaves grow they curl and protect the lice, so that from the time the buds begin to open till the leaves fall in autumn, it is almost impossible to destroy anywhere near all of the lice upon a large tree. If a few lice escape treatment, they increase so rapidly that it is but a few days before they are again very numerous and the owner of the tree concludes that his work was in vain.

REMEDIES.

To kill the eggs spray the trees very thoroughly before the buds open with one of the following preparations:

Whale-oil soap, - - - - - -	**1 pound**
Water, - - - - - - - - -	**2 gallons**

Shave the soap in small pieces and boil until dissolved and apply while warm.

Kerosene emulsion, - - - - - -	**1 part**
Soft water, - - - - - - - - -	**1 part**

Dissolve a pound of laundry soap in a gallon of water by boiling. Remove from the fire and add two gallons of kerosene and agitate as briskly as possible for a few minutes when all should be a creamy mass which will mix with soft water without the oil separating to form a film on the top. The agitation is best accomplished by using a good bucket force pump and pumping the mixture in upon itself through a spraying nozzle.

To this three gallons of emulsion add three gallons of soft water and spray at once. The preparation will now be one-third kerosene and will apply best while hot, or at least, warm.

The same preparations may be used against snow-ball and other plant lice. To be effectual, the application must be very thorough so as to reach every egg.

To kill the Lice. If the eggs have not been destroyed, the same preparations may be used to kill the lice, but in weaker strengths. The pound of whale-oil soap should be dissolved in 8 or 10 gallons of water and the three gallons of emulsion as prepared above should be diluted with not less than 27 gallons of water.

Another preparation that will kill well may be prepared as follows:

Tobacco stems or dust, - - -	1 pound
Water, - - - - - - - - -	4 gallons

First steep the tobacco in water enough to cover it for an hour at boiling heat and then dilute to the required amount—four gallons. Apply either hot or cold.

Do not add other substances to the above formulae but prepare just as above directed. If the applications do not kill it will be because the applications are not thoroughly made or because there was some error in the preparation. They are plenty strong enough.

If woolly aphis or black peach aphis appears upon the roots of nursery stock either may be destroyed by dipping in the tobacco decoction or the weak preparations of kerosene emulsion or whale-oil soap mentioned above, or the roots may be immersed for 5 to 10 seconds in water heated to 135 to 150 degrees Far.

THE CODLING MOTH.

The remedies of most use against this insect are arsenical sprays. Those that have been most successful are Paris green, arsenite of lime, arsenate of lead (also sold as Disparene), and "Paragrene." It does not matter so much what poison is used but to get very good results the spraying must be thorough and at the right time.

Paris Green or Paragrene may be used in Colorado in the proportion of one pound to 100 gallons of water. To this it is well to add two pounds of freshly slaked lime.

**Arsenate of Lead or Disparene* should be used in the proportion of 3 to 6 pounds to 100 gallons of water and without the addition of lime. The merits of this poison are—it will not injure foliage and it adheres better to the foliage than other poisons.

Arsenite of Lime is prepared as follows: Boil together for a half hour

White arsenic, - - - - - -	1 pound
Lump lime, - - - - - - -	2 pounds
Water, - - - - - - - -	3 gallons

Dilute to 200 gallons and apply. The addition of much larger quantities of lime to the mixture is probably harmful rather than beneficial.

When to Apply. First, as soon as the blossoms fall. Make a second application from 7 to 10 days later. If a third application is made, the best time for the warmer portions of the State is about July 4th, and for the cooler portions about July 15th. If the three sprayings as above directed are thoroughly done, it is very doubtful if additional sprays can be made to pay their expense. Of the three applications, the one just as the blossoms fall is by all odds the most important.

* Arsenate of lead may be obtained from the Bowker Insecticide Co., Boston, Mass., or Wm H. Swift & Co., 66 Pearl St., Boston, Mass.

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FORT COLLINS, COLORADO.

Fall Handling of Potatoes to Lessen Injuries from Insects and Fungi.

THE POTATO FLEA BEETLE.

(*Epitrix cucumeris.*)

BY S. ARTHUR JOHNSON.

The injury caused by this beetle to the potato harvest consists in mines made by the larval form under the skin or into the flesh of the tuber. The insect at this stage appears like a tiny worm as large around as a pin and perhaps three sixteenths of an inch in length. One may often see a portion of it protruding from the surface of a freshly dug potato. Its work is readily discovered by pealing a potato, when the discolored little holes will be quite conspicuous. These mines are most numerous near the surface, but may extend an inch or more into the flesh.

The worms now in the potatoes will develop into the adult, a minute black or dark brown beetle, which feeds upon the leaves of the potato and similar plants. When alarmed it has the power of jumping very quickly like a flea, whence its name. In patches where it is very numerous the leaves will often be found to be punctured with little round holes made while feeding. These may not be numerous enough to attract attention, however, even when the injury to the crop is considerable. The only sure way to discover the pest is to unearth hills in various parts of the field and examine the tubers carefully.

The potatoes are also injured in a manner resembling the above by the maggot of a fly which burrows under the skin producing a scabby appearance. The potato pulp about the burrow is brown and corky.

Efforts should be made at this time of year (September) to prevent, as far as possible, further injuries and to forestall the pest

next year. To accomplish this the potatoes should be dug as soon as their ripening will permit and, if possible, exposed to the air and sunshine for at least a few hours, preferably a day, before picking from the ground. When there is danger from freezing it will be impossible to leave the crop out of doors over night.

This treatment will largely prevent further depredations by the insect, but in case the damage should be continued in the stored tubers, some method of fumigation must be resorted to.

Of these probably carbon bi-sulfide will be the most satisfactory.

Carbon bi-sulfide is a volatile inflamable liquid which may be obtained in quantities at about ten cents per pound from Edw. R. Taylor, Cleveland, Ohio. In the ordinary potato cellar about one half pound to one pound will be necessary for each ten foot square of the floor surface.

To apply the fumigant the cellar must first be made very tight. Close the ventilators so that none of the fumes will escape. Make the door tight and prepare cloth or other material to pack around it when it is closed. Then shallow dishes or deep plates may be placed on the bins as high as is convenient. This is in order that the fumes, which are heavy, may settle down over the potatoes. When all is in readiness the dishes may be filled and the doors closed promptly and securely, and left in this condition until the following day when they may be opened and the fumes allowed to escape before anyone is permitted to enter.

It should never be forgotten for a moment that the fumes of carbon bi-sulfide are very explosive and poisonous. No fire of any kind should be allowed near the open can or in the building where the liquid is being evaporated. This caution applies to lighted pipes, cigars and lanterns.

The strong fumes when breathed for a short time produce unconsiousness which will result in death unless the sufferer is promptly supplied with fresh air. Bearing these things in mind, carbon bi-sulfide, in the hands of an intelligent person, is one of the most efficient fumigants with which we have to do.

The insects mentioned here will doubtless be most numerous next year in fields where potatoes were raised this year, and it is very desirable that next year's crop be planted entirely upon other ground.

Mr. E. A. Miller has kindly furnished the following suggestions with regard to the present crop.

"It is likely that much can be done to save potatoes from serious injury from the work of insects now infecting them by early digging. Care must be exercised, however, in this matter or rot and loss will follow. It is best to dig and allow the stock to remain in the sun for two or three hours before picking. This serves a very important purpose as it hardens the skin so the potato will keep better. In digging green stock a sorter should not be used as the greatest injury is done by it. The stock should be picked and poured carefully into wagons and spread shallow in the cellars until matured.

Many farmers do their stock great injury by rough handling. A potato is is nearly as tender as an apple when first dug and if badly handled the danger of

decay and blackening is greatly increased. The interests of the producer and shipper are in the end identical, as a reputation for good stock cannot be built up where the stock is badly handled."

E. A. MILLER, Mgr. Miller Produce Co. of Timnath.

FUNGUS DISEASES.

BY WENDELL PADDOCK.

Unfortunately the damage to the potato tuber does not stop with the insect injury. Various forms of fungi are abundant and ready to enter and extend any injury. It would not be surprising if the badly infected tubers would also rot badly. Early digging and exposure to the sun will not only kill most of the insects, but will be helpful in that some forms of fungi are also killed by exposure to the sun.

The necessity of handling green potatoes so as to avoid bruising, cannot be too strongly emphasized. Bruised surfaces on potatoes, especially if they are sacked, or placed in piles while the injury is still moist, invite the entrance of the germs of decay.

To sum up; it will probably be best to dig all potatoes infested with this worm at once. Allow the tubers to lie on the ground at least three hours, a half a day will be better. Do not use a sorter. Handle carefully and spread out as thin as possible in the cellar.

Twenty-Sixth Annual Report

OF THE

State Board of Agriculture

AND THE

State Agricultural College

INCLUDING THE

SEVENTEENTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

1904

DENVER, COLORADO
THE SMITH-BROOKS PRINTING CO., STATE PRINTERS
1904

THE STATE BOARD OF AGRICULTURE.

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* On leave of absence for two years. State Engineer, Denver, Colorado.

INSTRUCTORS AND ASSISTANTS.

GAVIN N. HOUSTIN, C. E.,
Civil and Irrigation Engineering.

ROBERT E. TRIMBLE, B. S.,
Meteorology and Irrigation Engineering.

J. H. BONEBRIGHT, M. S.,
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Physics.

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Mechanical Engineering.

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Mechanical Engineering.

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MARGARET MURRAY,
Stenographer, Directors' Office.

KATHERINE MURRAY,
Stenographer (Secretary's Office).

FLORA THOMAS,
Stenographer.

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CLARENCE P. GILLETTE, M. S...............Entomologist

WILLIAM P. HEADDEN, A. M., Ph. D..............Chemist

WENDELL PADDOCK, M. S.................Horticulturist

ROBERT E. TRIMBLE, B. S.....Assistant Irrigation Engineer

ANDREW H. DANIELSON, B. S......Assistant Agriculturist

B. O. LONGYEAR, B. S..............Assistant Horticulturist

EARL DOUGLASS, B. S.................Assistant Chemist

S. ARTHUR JOHNSON, M. S.........Assistant Entomologist

PHILO K. BLINN, B. S...............................
...............Field Agent, Arkansas Valley, Rocky Ford

JAMES E. PAYNE, M. S.....Plains Field Agent, Fort Collins

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MARGARET MURRAY..............Stenographer and Clerk

LETTER OF TRANSMITTAL.

To His Excellency,
THE GOVERNOR:

Sir—Herewith I transmit my annual report as Secretary of the State Board of Agriculture. It is respectfully commended to your attention and to the thoughtful consideration of the General Assembly:

A. M. HAWLEY,
Secretary the State Board of Agriculture.

The State Agricultural College,
Fort Collins, Colorado, November 30, 1904.

SECRETARY'S REPORT.

REPORT OF RECEIPTS AND EXPENDITURES CONNECTED WITH THE GENERAL FUND IN HANDS OF STATE TREASURER.

RECEIPTS.

Tax Fund	$63,984.73	
Tax Fund Voucher No. 519, returned	51.80	
		$64,036.53
Annie Jones Library Fund, balance Dec. 1, 1903	$ 605.80	
Annie Jones Library Fund	1,464.61	
		$ 2,070.41
Special Fund, balance Dec. 1, 1903	$ 36.52	
Special Fund	8,250.03	
Special Fund Voucher No. 68, returned	7.50	
		$ 8,294.05
Land Income Fund, Dec. 1, 1903	$ 135.54	
Land Income Fund	6,161.61	
		$ 6,297.15
Land Income Fund overdraft, Nov. 30, 1904		$ 2,661.51

DISBURSEMENTS

Overdraft Tax Fund, Dec. 1, 1903	$ 900.23	$83,359.65
Salaries	24,175.54	
President's Office	250.83	
Secretary's Office	255.44	
Library Department	1,856.56	
Horticultural Department	2,872.43	
Agricultural Department	10,789.00	
Chemical Department	1,724.16	
Mechanical Department	2,700.23	
Mathematical Department	16.00	
Physics and Engineering Department	752.50	
Zoology and Entomology Department	194.03	
Military Department	155.14	
History and Literature Department	47.25	
English and Sociology Department	16.70	
Domestic Science Department	430.25	
Commercial Department	384.85	
Veterinary Science Department	106.85	
Constitutional History Department	20.50	

DISBURSEMENTS—Continued.

Electrical Engineering Department	$ 595.99	
Furniture	1,513.10	
Insurance	311.05	
Current expense	2,464.86	
State Board of Agriculture	1,468.85	
General repairs	2,202.77	
Permanent Improvements	9,967.23	
Text Book Department	2,632.09	
Freight and express	1,343.96	
Fuel and lights	3,990.44	
Advertising	1,490.49	
Farmers' Institutes	563.55	
Catalogues and bulletins	417.68	
A. A. A. C. and exp. stations	15.00	
Student's labor	3,862.19	
		$80,477.74
Tax Fund, balance, Nov. 30, 1904	$ 1,706.60	
Annies Jones Library Fund, balance Nov. 30, 1904	1,175.31	
		$ 2,881.91
		$83,359.65

REPORT OF RECEIPTS AND DISBURSEMENTS OF FUNDS PAID INTO THE SECRETARY'S OFFICE IN CONNECTION WITH SPECIAL FUND, 1903-1904.

RECEIPTS.

Mechanical Department	$ 5.30	
Text Book Department	2,937.60	
Domestic Science Department	7.15	
Horticultural Department	87.25	
Freight, etc., refund	103.02	
Zoology and Entomology Department	10.00	
Physics and English Department	160.00	
Chemical Department	50.00	
Agricultural Department	3,725.51	
Gymnasium fee	169.00	
Entrance fee	984.00	
Library	1.00	
		$8,250.03

DISBURSEMENTS

Paid to the State Treasurer for credit of our Special Fund, as per receipts on file	$8,250.03

REPORT OF RECEIPTS AND DISBURSEMENTS OF THE UNITED STATES MECHANIC ART (MORRILL) FUND, 1903-1904.

RECEIPTS.

Deposit by United States Treasurer	$25,000.00

DISBURSEMENTS

Salaries	$25,000.00

REPORT OF RECEIPTS AND DISBURSEMENTS OF THE EXPERIMENT STATION FUND, 1903-1904.

RECEIPTS.

Remittance from United States Treasurer, turned over to the Experiment Station Treasurer, as per receipts on file..	$15,000.00

DISBURSEMENTS

Agricultural section	$ 477.80	
Chemical section	314.08	
Stationery	46.40	
Library	50.65	
Salaries	11,424.15	
Meteorology and Irrigation section	996.83	
Director's section	419.95	
Arkansas Valley sub-station	113.04	
Entomological section	225.40	
Printing bulletins	597.21	
Horticultural section	176.98	
A. A. A. C. and exp. stations	15.00	
Plains sub-station	142.49	
		$15,000.00

REPORT OF RECEIPTS AND DISBURSEMENTS OF FUNDS PAID INTO THE SECRETARY'S OFFICE IN CONNECTION WITH EXPERIMENT STATION SPECIAL FUND, 1903-1904.

RECEIPTS.

Meteorology and Irrigation section	$ 5.00	
Horticultural section	3.85	
San Luis Valley sub-station sales	1,090.59	
Director's section	11.65	
Arkansas Valley sub-station sales	202.50	
		$ 1,313.59

DISBURSEMENTS

Paid to the Experiment Station Treasurer for credit of our Experiment Station Special fund, as per receipts on file...	$ 834.19	
Balance in hands of Secretary, June 30, 1904	479.40	
		$ 1,313.59

REPORT OF RECEIPTS AND DISBURSEMENTS OF THE EXPERIMENT STATION SPECIAL FUND IN THE HANDS OF EXPERIMENT STATION TREASURER AND SECRETARY, 1903-1904.

RECEIPTS.

Meteorology and Irrigation section	$ 5.00	
Horticultural section	3.85	
San Luis Valley sub-station sales	1,090.59	
Director's section	11.65	
Arkansas Valley sub-station sales	202.50	
		$ 1,313.59

DISBURSEMENTS

Agricultural section	$ 484.40	
Meteorology and Irrigation section	181.54	
Director's section	12.05	
Entomological section	41.15	
Horticultural section	115.05	
Balance in hands of Secretary, July 1, 1904	479.40	
		$ 1,313.59

PRESIDENT'S REPORT.

To the State Board of Agriculture:

Gentlemen—This report deals with the general situation, having for its scope the entire institution under your charge. The heads of the various departments have prepared reports which I herewith submit giving in detail the work of the past year.

For five years we have been working together in good faith and good will to make this an institution for the more rapid and permanent development of Colorado and the Rocky Mountain region. Without in the least removing emphasis from other departments, we have sought to bring animal husbandry, plant husbandry, horticulture and veterinary science up to the common level of the other courses of study authorized and demanded by the federal government.

It has been our purpose, also, to make this institution less a preparatory school and more and more a technical school of high order. This may not have appealed so much to numbers, but it has greatly improved the quality of the work done and added much to the efficiency of those completing the various courses. Not only are the graduates of this school holding high rank among those of other institutions both eastern and western, but the demand for our men and women is four times greater than the supply. This certainly proves the character of the work we have done under your direction. You will be pleased to learn that the number of students in the Agricultural department has quadrupled as compared with last year with every indication that the number will be doubled next year. Still we shall not be able to meet the demands for trained workers. There have been enough calls during the present year for farm foremen and superintendents, experimental and government workers to take nearly every student in the department were he prepared. The same is true of the Civil Engineering and Irrigation department. Thus by imposing severe entrance requirements, lengthening the courses and holding every student to a strict account of his work, we have not thought so much of the enrollment as we have of the character of our output and the world's demand for high-grade men.

It can no longer be said that the Agricultural College of Colorado is a Fort Collins institution of little more than high school grade. The catalogue will show a marked decrease in the number of students from Fort Collins, but a much more general distribution throughout the State. We require four years after

graduation from an accredited high school, or from our preparatory school. No complaint comes from the student body by reason of the severe discipline and stiffer requirements, but rather, the often expressed conviction, that you have rendered them a lasting benefaction by so ordering their work as to have brought it to professional dignity and value. At the same time, I am firmly convinced that it is our duty to provide instruction for those young men from the farm who lack preparation, and on account of age, can not prepare for and take the long course.

I recommend, therefor, that a two years' course in agriculture be order prepared by the faculty, which, while it shall make the principles of agriculture and animal husbandry the major study, shall also provide such general English and mathematical training as may be deemed advisable. Such a course in mechanical engineering has been supplied by the College. Most of the students in that department have taken the long course since they can not become proficient enough to secure good positions without thorough grounding in mathematics. I think a two years' course in agriculture would be very popular and helpful.

In my last biennial report I stated: "We are searching far and wide for an able man for the chair of Agriculture." The search continued until we were satisfied. As a result, Professor Carlyle, formerly of the University of Wisconsin, has rendered us invaluable service for more than a year. You have loyally seconded his valuable and successful work by the purchase of valuable stock and arranging for the Andrews Farm, and securing for him more assistance in the department. He himself has added to our herds by valuable gifts from well-known breeders and importers and has started the whole State on a new road of stock breeding and meat producing that will be of incalculable benefit to the arid West.

The beet pulp feeding of last winter and the horse breeding experiment now about to be inaugurated by special appropriation secured from congress, alone rank your Agricultural College with the foremost of America. The recent commendation of Secretary Wilson is worth all the efforts have cost. We have justly received recognition as the leading Agricultural College of the Rocky Mountain region. A great work has been given us to do. Steadfastly we are rising up to its heroic measure.

I must congratulate you upon the acquisition of Professor Olin, formerly of the Agricultural College of Iowa. His co-operative work as an agronomist has put new life into the "rain belt," and a greater degree of courage and hope into the entire State. His record for doing things is so well known that he has already been able to secure for the College donations of farm machinery valued at more than three times his annual salary.

The short course you ordered to be inaugurated this winter is in readiness and I herewith submit the preliminary announcement. The indications for its success are more than gratifying.

The auditorium, with a seating capacity of more than 1,000, has been built since my last report. It was thought best to add a third story for recitation rooms. With the basement gymnasium, this magnificent addition stands the best of its kind in all the West, completed at a cost of $22,000. Many improvements on the farm and in the stock yards have been made during this time.

The Department of Electrical Engineering has been put into full operation. Nearly one-seventh of the students of this year have registered for this course or are preparing for it. The requests of Professor Crain submitted in his report are deserving of careful consideration.

We have reached a point now where the demand for more revenue is imperative. While the federal government has given us nearly seventeen thousand dollars this year for a special experiment, this experiment itself will draw somewhat from our regular funds. We must ask for still greater government aid. In this connection, let me urge you to give all possible support to the bill to be re-introduced before the national Congress this winter granting an additional annual sum to the experiment stations of Agricultural colleges. It will mean an increase in the efficient work of this station of two hundred per cent. It may be wisdom to send a representative to Washington to assist the executive committee of the Agricultural colleges and experiment stations in securing its passage.

Unquestionably we must have more assistance from the State itself. The agriculture of Colorado is the wonder of the whole country. A forward movement just now will soon give Colorado rank as one of the greatest agricultural, stock, and fruit states in America. With the administration of the Department of Agriculture friendly to us, willing to aid us in every way, with opportunity looming large just before us, it would be a shame indeed if for lack of funds we were to fail of our natural destiny. In what way we shall ask the State for larger aid must be left to your wisdom. I am sure the proper procedure will bring us the help we so sorely need. We never had so many friends, individual and organized, as at the present time.

I desire just here to put on record our appreciation of the invaluable work done by Professor Carpenter as State Engineer. Not only is he putting to rights the tangled affairs of irrigation in the State, but his work in the water suit of Kansas against Colorado, for which, as a worker in this institution, he has been long preparing, means the salvation of every agricultural valley of Colorado. We could ill have spared him from the chair of Irrigation Engineering for two years except for so great a cause.

I recommend that the improvements and repairs upon the Mechanical Engineering building, asked for by Professor Lawrence in his report, be made just as soon as funds are available. Now, that other institutions in the State are seeking to duplicate

our work in engineering lines and are laying special emphasis upon this effort, we must see to it that we keep so far in the lead that no one will doubt our loyalty to the compact which the State has made with the United States government by which $25,000 per year is appropriated from the government land funds for the maintenance of a State School of Agriculture and Mechanic Arts.

While I deplore the present competitive soliciting of students, against which I have always pleaded, it seems to be forced upon us as a present necessity. The fact that institutions have installed engineering lines similar to ours, and do most of their soliciting for students for these courses, compels us to, at least, set forth in a dignified manner our superior advantages. Our farmers' institute work and frequent visits to every agricultural portion of the State, keep constantly before the youth of Colorado the decided advantages of our agricultural courses. But field work of the highest order must be done next summer along all our lines of work if we be true to our mission and our obligations to the general government. To this end, I recommend that at least three members of the faculty be authorized to give a portion or all of their summer vacation to field work.

I recommend that Professor C. F. Griffith be given the chair of Animal Husbandry at a salary of $1,500 per year, and that both he and Professor W. H. Olin, of the chair of Agronomy, be made members of the faculty.

Lack of library room is one of our greatest problems. It is becoming a calamity. One-fifth of our books are boxed and stored beyond reach for lack of space. Magazines and pamphlets, so much in demand, are filed in basement rooms. Students have no room in which to read or investigate subjects assigned them. The Librarian, efficient as he is, is at his wit's end. I can see but one immediate solution, that I recommend with the concurrence of the faculty. It is the removal of the Commercial department from its present quarters and the giving of that building to the library. This will serve for a number of years to come. The change can be made at a cost not to exceed $250 to $350. It should be made during the next summer vacation. The Bookkeeping department can be given the new drawing room above the chapel and the Typewriting department the present library rooms.

I recommend that all proper means be used to induce the coming Legislature to increase our present mill tax. The regular expenses of maintaining so great and important an institution are not adequately met by the present one-fifth of a mill. It is the common conviction that the Agricultural College is doing more for the enrichment of Colorado that any other institution. The greatest growth of the State during the next decade will be along agricultural lines, as has been true of the last decade. It is only fair and just that the State shall materially assist in directing this growth. Every thousand dollars invested now in

scientific agriculture will mean one hundred thousand dollars to the State within the next twenty years. As evidence of this, I cite our recent experiments in beet pulp feeding, the raising and milling of macaroni wheat, and sugar beet growing, as well as our experiments in feeding upon native grown foods. The proposed horse breeding experiment has attracted the serious thought of the entire nation and will mean greatly increased wealth for Colorado.

I can not close this report without a word of appreciation of the harmony and good will which prevail in faculty and student body. Despite the fact that the severe process of stricter discipline and sterner requirements in scholarship is going on, satisfaction seems to be general. We are almost ready now to begin to build a larger enrollment upon this new basis; an enrollment which will count for something. Our students will be such as will remain for a number of years, instead of so many being birds of passage. When they go from us they will go in loyalty and in enthusiastic support of the College. This, after all, is our greatest achievement.

Respectfully submitted,

B. O. AYLESWORTH,
President.

DEPARTMENT OF AGRICULTURE, 1904.

Colorado State Board of Agriculture:

I have the honor to present for your consideration the following somewhat detailed report of the Agricultural department of the Colorado Agricultural College for the year just past:

In the last annual report a number of suggestions were submitted for your consideration, looking to the improvement of this department. Some of these have been accomplished under your direction, while others of equal, if not of greater importance, have had to be held in abeyance for lack of funds with which to carry on the work. On the whole, the Agricultural department of the College has gone steadily forward, and a brief resume of what has been accomplished may prove interesting, and will lead up to some work that it seems important should be undertaken in the near future.

The teaching work in the College during the past year was not heavy, owing to the limited number of students and to the comparatively small amount of work that was offered in the department.

When the catalogue was revised for publication this year some very much desired changes were made in the course of instruction offered. The schedule of studies for first and second sub-freshmen students, which constitutes a preparatory course of study for the regular college course, remains about as it was. The mathematics required in these two preparatory years of study, and also in the freshman year of the regular college course, is much heavier than should be required of young men coming from the farms and electing the Agricultural course. It results in many of the very best agricultural students having to leave the regular course of study and either returning to their homes, going to some other school away from all agricultural environment, or going into the commercial or other special courses offered. In the old schedule no agricultural studies were offered in either of the sub-freshman years nor in the regular freshman year, while the new course now gives five hours of regular classroom work in agriculture each week during the freshman year and approximately five hours per week of practice as well.

In the sophomore year, the new course gives four hours per week of regular class work, and at least five hours per week of practice more than was offered in the old course. In the junior year, at least five hours per week more of regular class work is offered in agriculture than has been given heretofore.

Another very important change has been made in the course, whereby the students in all branches of the Agricultural department of the College are given the same course of study during the freshman and sophomore years. On beginning their junior year's work, they may elect one of five branches as their major study and specialize in that with a sufficient amount of closely allied studies to round out their course and make it strong on all points touching the major study. This plan simplifies the teaching and tends to make strong students in the particular branch which they have chosen.

We now have twenty-one students in the freshman class, all of whom, with one exception, have passed creditable examinations in this department in the last term's work, and are going steadily forward in the work of the present term.

SHORT COURSE FOR STOCKMEN AND FARMERS.

In accordance with your instructions at a called meeting of the Board, held in Denver last winter, a short course in Agriculture for mature stockmen and farmers has been offered. Over 5,000 circulars descriptive of this course have already been distributed, and the outlook is very bright for a large attendance of the leading stockmen and farmers of this State upon this course. Should this course be the success we anticipate in the matter of attendance, some provision should be made in the matter of class-rooms and other accommodations for the perfection of the course.

Farmers' Institutes. During the past year a number of farmers' institutes have been attended, and this work on the part of the College seems to be greatly appreciated. This was particularly true of the potato institutes, a number of which were held in the early part of the year. It is hoped that during the coming year this work may be broadened and extended so as to include various other branches of agriculture.

During the year, in preparation for the further development of this department and looking forward to the increase of work devolving upon it through the holding of the short course for farmers, and the call for extensive field work, Prof. W. H. Olin was secured as an assistant in Agronomy, and his work has already been very favorably received by the farmers of the State.

Before entering upon the detailed work of the department, it is with pleasure that I report the efficiency of the work performed by Assistant Professors C. J. Griffith and W. H. Olin, and Assistant A. H. Danielson, as well as the other members of the farm force, particularly of the farm superintendent, Wm. O'Brien, who has been most faithful, efficient and diligent in carrying out the detailed work of the farm. The office work in this department has grown immensely in the past year. The correspondence has quadrupled and the bookkeeping work

which has been inaugurated for farm accounts is being well carried on by our very efficient secretary, A. D. Milligan.

LIVE STOCK ON THE COLLEGE FARM.

Cattle. As your Honorable Board will remember in my last report, I mentioned the condition of the live stock on the farm. During the year a number of the poorer Shorthorns have been disposed of at remunerative prices. Two or three choice individuals of this breed have been added, and we still have a surplus, which we hope to dispose of during the next few months. Early in the spring the College secured on very advantageous terms the entire herd of imported Aberdeen Angus cattle belonging to Mr. J. C. Osgood. The first arrangement under which we secured the cattle was that the College should have such animals of this herd as they wished to keep for breeding purposes without any cost. The surplus not required by the College was to be sold and the proceeds turned over to Mr. Osgood. One-half of the produce of the animals to be kept in the College herds was to be turned over to Mr. Osgood to be disposed of by him as he deemed best. Before any part of this agreement could be carried out, Mr. Osgood very generously agreed to denote the entire herd to the College. The animals not required by the College were to be sold, and the proceeds were to be put into a loan fund, to be used in aiding deserving agricultural students who had not funds of their own sufficient to carry them through their college course. Also one-half of the produce of the animals kept in the herd from Mr. Osgood's donation were to be sold, and the proceeds to go to this fund, which was left in the hands of a committee consisting of Dr. Aylesworth, Hon. E. H. Grubb, and the head of this department. So far only one animal has been sold, for which we realized $500. This money will go into the loan fund for students. We now have on hand for sale from this herd of Aberdeen Angus cattle, two yearling bulls, two cows and five young calves of varying ages. During the year we have also added to the herd by purchase and donation, two very superior Holstein cows and a bull, two Red Polled heifers and a bull calf, a West Highland cow and a number of choice young steers, for experiment and demonstration purposes. Of these, the Grand Champion Holstein cow of the World's Fair, at St. Louis, was donated by Hon. R. M. Hotaling, of San Francisco, California. Also, the reserve to champion bull, Lakeside Missouri Chief, donated in part by Mr. Hotaling and in part by Mr. M. E. Moore. of Cameron, Missouri. One of the Red Polled heifers was donated by Andrews Brothers, of Ohio, and one by H. G. Henderson, of Central City, Iowa. The Red Polled bull was donated by Mr. J. W. Martin, of Richland City, Wisconsin. A pure bred Shorthorn steer was donated by Mr. Robert Andrews, of Fort Collins, and three Shorthorn steers were given to the College by

Cary Brothers, of Routt county, Colorado. At present we are somewhat overstocked with cattle, but when those not desired for demonstration or experiment work have been disposed of, we will have on the College farm as good a representative herd of live stock in the cattle class as may be found on any college farm in the country, with one or two exceptions.

After consulting with the President of the College and the Chairman of the Farm and Stock Committee, it was decided to offer all the surplus stock on the College farm at public auction on the 21st day of January, which date occurs midway in our Short Course. This will insure a wide distribution of the stock, and, at least, fair prices.

Sheep. At the time of your last annual meeting we had the representatives of but one breed of sheep on the College farm, and of this breed we had some twenty-six head. During the year most of these have been disposed of at remunerative prices, and only the best animals in the flock have been reserved. There has been added, partly by purchase, and partly by donation, a trio of prize-winning South Downs, from the flock of George McKerrow, of Sussex, Wisconsin. Of these, the ram was purchased, and the ewes donated. We have also secured from the same party three very choice prize winning Oxford ewes, all safe in lamb, which were secured at about one-half their value. We have also secured a trio of French Merino sheep, of mutton type, from the flock of Frank Harding, of Waukesha, Wisconsin. These animals were imported from France, and we secured the three for a little more than one-half of the cost of one of them in France. At the recent International Live Stock Show, at Chicago, two very choice Shropshire rams were donated to the College for use in our classroom work with students. One of these was presented by Dr. G. Howard Davidson, of Millbrook, N. Y., and the other by Mr. John Campbell, of Woodville, Ontario, Canada. We now have, therefore, four of the leading breeds of sheep represented on the College farm, and all of them excellent types.

Swine. Our swine department has advanced almost as much as either of the two departments before mentioned. We have secured during the year two very choice Berkshire sows, one from N. H. Gentry, of Sedalia, Missouri, for which we paid $75, although on the day prior to purchase Mr. Gentry had refused $200 for her. The other sow, equally good, was secured from Mr. G. C. Council, of Vandalia, Illinois, at about half her value. A donation of a Berkshire sow and a boar was also made by Cary Brothers, of Routt county, Colorado. We now have four breeds of swine well represented.

Horses. In the horse department we are still somewhat light in our representation, though we hope for something substantial in this department in the near future. At the recent International Live Stock Show, one of the largest horse breed-

ing and importing firms in America, Dunham, Fletcher & Coleman, of Wayne, Ililnois, donated the services of one of their most valuable stallions to our College. This horse is about 20 months of age, and is loaned to us without cost except his maintenance, for demonstration, and for service on such mares as we may care to breed to him. We are to keep this horse until we can dispose of him to advantage for them, or, in case we wish to return him at any time, they will accept of him. This will be the only representative of a pure-bred horse of any kind that we have on the College farm.

Proposed Horse Breeding Experiment. At your last annual meeting, a committee, consisting of Dr. Aylesworth, Mr. Grubb and myself, were appointed to go to Washington and secure, if possible, some aid from Congress, through the Department of Agriculture, to carry on some work looking to the improvement of live stock in the Inter-mountain region. Your committee immediately took steps to accomplish this work, with a success that was very gratifying, and so generous that it was somewhat of a surprise. Twenty-five thousand dollars was appropriated by the federal government to the Department of Agriculture, to be used in carrying on experiments in the breeding of live stock in connection with the various experiments stations in the United States. Very naturally, since the idea originated with your Honorable Board, this College was the first to receive consideration at the hands of the Secretary of Agriculture. After many conferences between the Department of Agriculture and members of the above mentioned committee, an agreement has been reached, and it is submitted herewith for your approval, looking to the carrying on of extensive experiments in the improvement of carriage horses in the United States. The following is a full text of the agreement, which it is hoped may meet with the approval of this Board, in which case steps will be taken at once to inaugurate this work at our College:

UNITED STATES DEPARTMENT OF AGRICULTURE, OFFICE OF THE SECRETARY.

AGREEMENT RELATING TO A CO-OPERATIVE EXPERIMENT IN HORSE BREEDING.

This Agreement, made and entered into this 21st day of December, 1904, by and between James Wilson, Secretary of Agriculture, for and on behalf of the Department of Agriculture of the United States of America, party of the first part, and W. L. Carlyle, an officer of the Colorado Experiment Station, for and on behalf of the said station, party of the second part.

Whereas, The parties to this agreement desire to conduct a co-operative experiment in horse breeding, under the terms of the annual appropriation for "Expenses, Bureau of Animal Industry, 1905," under the subhead "Animal Breeding and Feeding," upon

the farm of the Colorado Agricultural College, and to study the possibility of evolving an American carriage horse from the American trotter.

Now, this agreement, witnesseth:

First. The party of the first part for the considerations hereinafter mentioned, agrees to and with the party of the second part as follows:

1. To secure at the earliest practicable date, at least twenty mares of carriage type and one stallion of carriage type, and to deliver the said mares and stallion to the party of the second part, f. o. b. at the railroad station nearest the said designated farm. *Provided,* That the said horses shall be purchased for the United States by a board of three competent persons, one member to be an officer of the Department of Agriculture, to be appointed by the party of the first part, one member not an officer or employe of either the Department of Agriculture, or the said station, to be appointed by the party of the first part, subject to the approval of the party of the second part; and one member who shall be an officer of said station to be appointed by the party of the second part; and, *provided, further,* That the party of the first part shall defray the traveling and subsistence expenses of the said board while the members are actually engaged in the selection of the horses, the said expenses to be governed by the fiscal regulations of the Department of Agriculture, unless otherwise ordered by the party of the first part.

2. To pay salary at the rate of one thousand dollars per annum to an expert in charge, to be named by the party of the second part, such designation to be approved by the party of the first part; to pay the salary of an expert groom. This expert groom shall be selected by the expert, with the approval of the party of the first part, and shall devote his time to the care of the said horses and be immediately responsible to the expert in charge for the care thereof, but the said groom may be required to assist in instruction in horse husbandry at the Agricultural College; and to pay a further sum not to exceed fifteen hundred dollars during the present fiscal year to partly cover expenses of equipment and maintenance.

Second. The party of the second part, upon condition that the party of the first part faithfully perform each and every provision hereof, agrees to and with the party of the first part as follows:

1. To keep and maintain in the best manner the horses covered by this agreement, and their progeny, upon the farm of the said station or upon the farm of the Colorado Agricultural College, and to furnish necessary pasture, feed, care, attention, training and equipment, without expense to the party of the first part, except as herein otherwise provided for.

2. To keep a stock record of the breeding of all horses in the stud at the said station, and of all their progeny. The said record shall contain the dates of breeding of mares, with names and numbers of mares and names and numbers of stallions to which they are bred, the dates on which foals are dropped, with names and numbers of sire and dam in each case, and the deaths and transfers of all animals. This information shall be furnished to the party of the first part as soon as it is available, and the record shall be kept on forms furnished by and in a manner satisfactory to the party of the first part; and all books and records pertaining to the experiment herein provided for, and kept by the party of the second part, shall at all times be open to the inspection of the party of the first part or his accredited agent. The party of the first part reserves the right to establish a general stud book for American carriage horses.

Third. The parties hereto further agree as follows:

1. That the progeny of the animals furnished by the party of the first part shall, except as hereinafter provided, be and become the property of the party of the second part, subject to an option in the party of the first part to purchase any and all progeny at an agreed price; but the party of the second part shall not sell any of the said progeny without the written approval of the party of the first part. When the progeny is sold, the proceeds shall be applied by the party of the second part to the continuation of the work of carriage horse breeding, subject to all conditions and limitations of this agreement.

2. That the stallion or stallions covered by this agreement may be used for service on mares not otherwise covered by this agreement, if the demands on them will, in the opinion of the expert in charge, permit such service, and if the mare is in each case acceptable to said expert. In every case the record of such breeding, including the name and owner of mare at time of service, name and number of mare and name and number of stallion, shall be forwarded immediately to the party of the first part by the expert in charge. A uniform service fee on mares not covered by this agreement shall be fixed by the said expert, the rate to be approved by the party of the first part, and the money so obtained shall be applied in the manner and for the purposes hereinbefore set out for the proceeds of the sale of progeny of the original herd.

3. That in case either party to this agreement desires to withdraw from the experiment, then six months' notice in writing shall be given to the other party thereto, in which event, all the animals furnished by the party of the first part, together with so many of the progeny as may be desired by the party of the first part for breeding purposes, and all trappings and equipment for the horses purchased with funds supplied by said first party shall revert to the party of the first part, and shall be the absolute property of the United States. *Provided*, That if any of the orig-

inal herd shall have died, a number of the progeny equal to the number of deaths shall be taken by the party of the first part without compensation to the party of the second part, but if a number of the progeny in excess of the number of deaths be desired by the party of the first part, then the party of the second part shall be compensated for the said excess at a price to be mutually agreed upon.

4. That the result of this co-operative experiment may be published by either party to this agreement, but no such publication shall be made by either party without the approval of both parties obtained in advance of publication.

5. That it is an express condition of this agreement that no member or delegate to Congress shall be admitted to share any interest therein or to any benefit to arise therefrom, and that said agreement shall be subject in all respects to the provisions of sections 3739, 3740 and 3742 of the U. S. Revised Statutes, so far as the same may be applicable.

6. That the Secretary of Agriculture may, in writing, from time to time, delegate to any officer or person in the employ of the United States of America, with the same effect as if such officer or person were specifically named herein, every right and power hereby conferred upon the said Secretary, with reference to the conduct of this experiment, and until the party of the second part shall receive notice in writing to the contrary, said rights and powers shall be deemed to be delegated to the chief of the Bureau of Animal Industry.

In Witness Whereof, The parties hereto have executed this agreement in triplicate, at Washington, on the date first above written.

JAMES WILSON,
Secretary of Agriculture, Party of the First Part.

W. L. CARLYLE,
An Officer of the Colorado Agricultural Experiment Station,
Party of the Second Part.

It will be observed that on the part of the department no mention is made of any assistance beyond the present fiscal year ending July 1. The reason for this lies in the fact that none of the departments of the federal government can enter into an agreement which anticipates an appropriation. Your committee, however, has the assurance of Dr. Salmon, who represents the Department of Agriculture in this work, that such funds as are reasonable will be forthcoming from time to time to carry on the work.

Agronomy. An outline of the proposed plan of work for the coming year in Professor Olin's department is submitted here-

with. An outline of the approximate sums of money required for carrying out of these plans as well as to provide for the accommodation of the horses to be used in the horse breeding experiment and to supply the growing needs of this department have been submitted on a separate report to your Secretary, which I trust may have favorable consideration at this meeting.

In conclusion, I wish to thank each and every member of the Board for the loyal support and aid given in furthering the work of this department. My thanks are especially due to Dr. Aylesworth, President of the College, and to Secretary A. M. Hawley, for the consideration they have shown me in carrying on the work under the enforced lack of funds that the College has experienced during the past year.

Respectfully submitted,

W. L. CARLYLE,
Professor of Agriculture.

REPORT OF THE AGRONOMY WORK OF THE DEPARTMENT OF AGRICULTURE, DECEMBER, 1904.

To Professor W. L. Carlyle,
Professor of Agriculture,

Colorado College of Agriculture.

Dear Sir—I take pleasure in submitting to you the following report of the work in the new Department of Agronomy, which the State Board of Agriculture organized in June of the present year:

I closed my work at the Iowa State College July 1, and reached Fort Collins as soon thereafter as possible.

My first care was to become familiar with crop conditions in as many parts of the State as possible. A thorough knowledge of these conditions will enable me to more intelligently direct the students in class, as they study the farm crops of this and other states.

Agronomy is a science of the field and its crop.

In our college work we shall undertake to carry out the following lines of work:

Freshman Year—Farm mechanics; *Sophomore Year*—Farm crops; *Junior Year*—Soil fertility; *Senior Year*—Farm management.

This present year we started the Agronomy work by organizing a class in farm mechanics. Farming at the present day is very largely done by the use of machinery. Hence it is necessary for the student of agriculture to study the mechanism, action and relative value of the different farm implements.

In this new course, we study farm machinery, farm buildings, farm motors, farm fences and the construction and maintenance of country roads. No provision was made for a class laboratory period, but the students devoted a part of each Saturday to this work, and I am impressed with the importance of granting an afternoon laboratory twice a week for students to perform detail work that seems essential for the complete understanding of the subjects discussed.

While studying plows, the class took part in a plowing match that awakened much interest in this very important field operation.

Each student was required to turn a back furrow and plow one-tenth of an acre.

His work was judged on the following points by Mr. William O'Brien, Superintendent of the College farm:

		Points.
1.	Line of furrow	15
2.	Uniform depth of furrow	15
3.	Uniform width of furrow	15
4.	Trash covered	15
5.	Manner of handling plow and team	10
6.	Top line furrow	5
7.	Back furrow	10
8.	General appearance	15
	Total	100

I am convinced that a plowing match should become a permanent feature of our work in this course. It will help to impress upon the students the value of good plowing. For this contest Mr. W. H. Sears, general manager of the John Deere Co., Denver branch office, presented a $20 fourteen-inch walking plow to the one who was judged the best plowman at this match. Mr. L. M. Montgomery was awarded this prize. The book, stationery and notion dealers of Fort Collins presented $12 worth of merchandise for a second prize. This was awarded to George L. Penley. The implement dealers of Fort Collins presented $5 worth of merchandise as a third prize, which was awarded to Mr. Alfred Chace. Mr. John Deere presented an oxidized silver watch fob as a fourth prize. Mr. F. M. Gum was awarded this present from Mr. Deere.

Our College farm has a limited amount of farm machinery, much of it being unserviceable and therefore not adapted for use in class. I appealed to firms manufacturing farm machinery for help. Many of these kindly agreed to place machines with us for class study and field demonstration purposes. I was pleased with the interest and earnestness manifested on the part of the freshmen who took this work.

We must needs extend the length of time of shop and class instruction in farm mechanics to give the student the knowledge modern farming seems to require of its manager.

I have arranged for all freshmen students, who can do so, to spend their summer vacation on a large ranch, at remunerative wages.

During their junior and senior years of the College course, I desire these students to have employment on a well managed ranch, where general farming is practiced. They will then be asked to study the manner in which the farm is managed, preparing them to realize the importance of farm management which is given in the Agronomy work, in senior year. I feel that six

months on a well managed farm, in actual field practice, will be a valuable addition to their college work and will make our students more competent and efficient to successfully solve the practical problems of the farm.

We have already had several calls for farm managers, and I regret to state that we have not had the students prepared to take these positions. It is my purpose to make our class work in Agronomy—farm mechanics, farm crops, soil fertility and farm management—as practical and preparatory for successful farming as possible.

Thanking you for your many courtesies to me, I submit to you this brief report of work just started.

W. H. OLIN,
Associate Professor of Agronomy.

Fort Collins, Colo., November 30, 1904.

ANIMAL HUSBANDRY.

Report 1904.

Prof. W. L. Carlyle,
Professor of Agriculture,
Colorado Agricultural College.

Dear Sir—I have the honor herewith to submit the following report of the work done under your direction for the past year in animal husbandry:

As you are aware, the teaching has been increased along animal husbandry lines in the past year, and, while the work offered is still limited, and the enrollment of students small, it consumes considerable of the time of one instructor. During the fall term of 1904 I taught classes in the following subjects: Breeds of Live Stock, five hours per week; Feeds and Feeding, four hours per week; Judging Market Classes of Sheep and Swine, five hours per week; Judging Breeding Classes of Sheep and Swine, five hours per week. In the four classes there was a total of fifty-four pupils. Fourteen of these were special students, and were enrolled to do judging work with the regular students. The four valuable medals secured by your efforts, and so kindly presented by Messrs. Stubbs and Springer, of Denver, and by the Oldenburg Coach Horse Association, of Oldenburg, Germany, were contested for by twenty-nine students. The competition took place at the Colorado State Fair, at Pueblo. In the judging of Belgian draft horses, Mr. C. C. Officer won first place; Mr. N. J. Miller, second place; and Mr. C. E. Miller, third place. In the judging of Oldenburg coach horses, Mr. W. J. Morgan won first honors; Mr. L. C. Gilbert, second; and Mr. N. J. Miller, third place. The work done by all the students in this competition was very creditable, and excited considerable interest in the College.

Mr. A. H. Zenner, of the Zenoleum Disinfectant Company, Detroit, Michigan, offered a medal for the best write-up of any three classes of stock judged in the regular competition of the Fair Association. The papers presented in this competition were all good, and showed the great interest taken in the work by the students. Mr. O. L. Prien wrote the best paper, and was presented with this medal. Some valuable work was done by the students in judging rings of cattle and hogs, besides the competition judging.

Besides the above mentioned classes, I taught a special class in stock judging. This class was made up of senior and post-graduate students.

Some experimental work was undertaken, part of which has been completed.

Two sets of eggs were incubated. The first set consisted of 120 pure-bred eggs of five different breeds. Twenty-three eggs were tested out as non-fertile. A hatch of 60 per cent. of the remaining eggs were taken off. A second set of chicken and turkey eggs gave a 59 per cent. hatch of chicken eggs. The turkey eggs hatched poorly. There were a great many non-fertile eggs, and the germs of the fertile eggs seemed very weak. Out of thirty eggs put in the incubator, thirteen were non-fertile, and only five eggs hatched.

For three seasons past some work has been done in soiling dairy cows. This present year, one-eighth acre plots were put in of oats, rape, millet, State of Maine flint corn, Evergreen sweet corn, and Kaffir corn and sorghum. The oats yielded at the rate of 24,864 pounds per acrė of green fodder. The millet yielded at the rate of 19,584 pounds of green stuff. The State of Maine flint corn at the rate of 32,760 pounds per acre. Sweet corn. 23,-520 pounds per acre. The sorghum, 46,000 pounds per acre. The Kaffir corn did not do much, and was not weighed. The main soiling crop used was alfalfa. It was ready to use by the middle of May, and was used steadily until September 5. The other crops grown were used incidentally, and were not as palatable to the cows as alfalfa. The rape was fed to the young stock and to the sheep. It yielded in two cuttings, twenty-five tons per acre. That this system, or at least a partial soiling system, is a profitable one for our farmers to follow, can be seen from the following yields of our dairy herd:

MILK RECORD OF AGRICULTURAL COLLEGE DAIRY COWS. 1904.

Cows	May, lbs.	June, lbs.	July, lbs.	August. lbs.	September, lbs.
Black	1,653	1,463	1,417	1,297	1,096
Bessie	1,196	1,095	1,130	1,025	910
Sybil	1,446	1,367	1,289	1,068	873
Duchess	1,201	1,307	1,251	1,100	932
Total	5,496	5,232	5,087	4,490	3,811

The pig feeding experiment conducted on the farm gave some interesting results, showing that a large profit can be realized from raising and fattening hogs on our ranches. It also showed the great value of rape as a hog pasture. The lot pastured on rapė and fed a liberal quantity of grain required a less amount of feed to produce a pound of gain than the lot similarly fed, but pastured on alfalfa. Some experiment work was done with feeding refuse molasses from the beet sugar factories. The pigs on this experiment were fed in a closed lot, and were given no green feed whatever. The grain consisted of a mixture of equal parts

shorts and corn. The molasses was mixed with water and the grain put in this sufficient to make a thin slop. Molasses was also put in their drinking water. This latter was relished greatly by the pigs, for, after a time, they would not drink water that did not have molasses in it. The pigs averaged 83 pounds each at the time this experiment began, and 212 pounds each at the close. They were fed 107 days. It took 3.3 pounds of grain, and 1.8 pounds of molasses, for each pound of gain. At local prices for grain and molasses, the cost of each pound of gain was 3.61 cents. Considering that no pasture was used, I think that these results show a high feeding value for molasses. The pork from these hops was very fine, both the fresh meat and the cured bacon and ham.

The records of the pure bred stock on the farm are up to date, and all stock one year old and over are recorded in the stock books of their separate associations.

Respectfully submitted,

C. J. GRIFFITH,
Associate Professor of Animal Husbandry.

REPORT OF THE DEPARTMENT OF VETERINARY SCIENCE.

To the State Board of Agriculture:

Gentlemen: The following report is respectfully submitted as an outline of work done in this department during the year 1904:

In a previous report I suggested that it would be well to determine upon a more or less permanent policy to direct the future of this department, and that upon investigation of the character of similar work in other institutions I found that one of two policies was generally in vogue: First, to properly equip and maintain a complete course leading to a Veterinary degree, with everything conserving to make this the prime object in view. Second, to limit the instruction to a short practical course of lectures adapted more especially to the students in agriculture, and with well equipped laboratories and assistants to work in conjunction with the Experiment Station, and in closer touch with the live stock interests of the whole State. To me this has been, and still is, the momentous question, whether, in substance, our goal shall be the Veterinary College, such as Ames and Cornell, or primarily experimental investigation such as at Lincoln, Nebraska, or Auburn, Alabama.

Previous to this year, not being connected with the Experiment Station, our only alternative was to strive to build up as complete a course in veterinary science as existing conditions would permit.

Our efforts to this end have not only demonstrated the need for this sort of instruction, but further, that a complete course well equipped and leading to an appropriate degree, would receive ample support.

Wishing to follow along one line or the other, and not try to stride two horses going at diverging angles and deeming the first plan not exactly feasible at this time, I recommended the other, and accordingly asked to be placed on the Experiment Station staff, and to have the course of study re-arranged to this end. This request was granted, and for which I thank you.

In the curriculum, as now arranged, all students in the agricultural division take the same work for the first two years, and at the beginning of the junior year there is the opportunity to choose between Veterinary or any of the other courses, in this division.

This arrangement is very satisfactory, and certainly insures a very high order of veterinary attainment by laying a broad and secure foundation.

The difficulty now is that there is a constant demand by both young and middle aged men for exclusively veterinary instruction, and who are not sufficiently qualified, educationally, to matriculate for the work where it is now given. We can not place the work lower down in the course to accommodate these applicants without lowering the present high standard, and encouraging charlatanism. I believe it will be well to consider the advisability of giving a two years short course for such applicants.

Largely through the effort and influence of E. H. Grubb, at Washington, I received from the Department of Agriculture a three months' appointment as expert investigator of scabies in cattle, and poison weeds on the Western Slope, beginning June 15. The College, wishing to co-operate in this work and make it as thorough as possible, several animals badly infested with scab were donated by enterprising stockmen of Yuma county, they were transported to College by the railroads without charge, and having the desired subjects accessible at all times will greatly facilitate the work. Among the important things, we wished to make a careful study of the life history of the parasite, and by the use of various crude oils, and standard dips, determine, if possible, the most economical and effective way of coping with this vexing problem.

Because of the fact that the parasite is inactive during the fall and early winter months, the work has been practically at a stand still, but will be taken up later when conditions are favorable and the report will follow in due time.

Poisonous plants on the range. I believe that it is generally conceded that there is no place on earth where the live stock industry flourishes under more favorable conditions and more unhampered by the ravages of disease, contagious and otherwise, as in this arid region of the United States.

In this State the greatest annual mortality on the open range, under the present regime, is not from disease nor perhaps from exposure, but from various poison weeds which grow native and to a less extent in cultivated fields. The stockmen have, on this account, in many cases, become greatly discouraged and quit the business or abandoned otherwise good ranges.

While one of several plants are in each case thought to be responsible, yet there will not be two men in a community who will agree as to the identity of the plants responsible, or the best means of dealing with the matter.

The annual loss from this source in the aggregate is very heavy. There is great need of education among the range live

stock men on this subject. The localities where these particular plants flourish should be defined, their identity made easy and the time of year when they are most dangerous and are to be avoided should be the subject of careful investigation.

My report to the Department of Agriculture on last summer's investigation of range conditions on the Western Slope, will be printed and made accessible in the near future.

Other diseases. The ravages of blackleg have been successfully checked wherever proper vaccination has been tried. At present it is the only hope we have of reducing the mortality of this dreaded disease of young cattle.

By an eternal vigilance on the part of our State live stock sanitary officers, glanders, southern cattle fever, and, in fact, all of the infectious and epizootic diseases have been kept under complete control. Tuberculosis among the milch cows in the dairies, supplying milk to our cities, is not an uncommon thing.

The unisity of tuberculosis in man and the bovine is settled in the minds of nine-tenths of the scientists now living, and the transmission of this dread disease by milk of the cow is generally conceded. There should be a rigid health inspection of all dairies within the State.

Needs of Department. Beyond a few incidentals, we are not in need of anything at present. Our present quarters in the basement of the Commercial building are somewhat unsanitary and are inappropriate, and in a short time will be entirely inadequate. All we ask for in the future is what we have had in the past, i. e., what we deserve and what our condition seems to demand.

Respectfully submitted,

G. H. GLOVER,
Veterinarian.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND BOTANY.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit the report of the Department of Horticulture and Botany for the year 1904.

The instruction for the year has followed the schedule as published in the catalogue, with the exception of nature study. Five hours per week of this work during the fall term was allotted to the department instead of the two hours that had usually been given. Arrangements were made whereby Mr. Payne, of the Experiment Station staff, was detailed to take charge of these classes. I wish to take this opportunity of expressing my appreciation of the satisfactory manner in which Mr. Payne carried this heavy term's work through to completion.

Mr. F. M. Rolfs, who has been associated with me in the department for four years, resigned in August, to accept the chair of Horticulture and Botany in the Agricultural College of Florida. The place has been filled by Mr. B. O. Longyear, of the Michigan Agricultural College. Mr. Longyear has had ten years' experience as a teacher of botany, and was for two years botanist of the Experiment Station, so he comes to us well equipped for the work.

A number of terms' work in both horticulture and botany have recently been added to the course, consequently another assistant is sorely needed. At present our time is nearly all occupied with teaching and routine duties, leaving almost no time to devote to investigation. And should one of us be called away from the College for a day, some of the classes would have to be suspended.

Campus. Some improvements have been made in the campus during the past season which need not be enumerated here. Our plan has been to make the remote corners and by-places presentable and thus make a unified whole. We are planning for some extensive improvements the coming season, but the only work for which money will be needed will be for curbing along the north and east sides of the campus. The parking outside of the sidewalks adds very materially to the appearance of any property, and this can not be done along College avenue without a curb to hold the earth in place.

Greenhouses. I desire to call your attention once more to the unsatisfactory condition of the two older greenhouses. They are hardly worth spending enough money on to put them in first-class condition. However, one man worked five weeks on these

houses this fall, getting ready for cold weather, and some money was expended for repairs.

Equipment. For the first time, I find it necessary to ask for more equipment. The increased number of students taking work in botany, make the purchasing of more microscopes and accessories imperative. We ask for an appropriation of $237.90 to meet these wants.

The equipment along other lines is adequate for the present. The only difficulty being that we do not get sufficient time in which to make use of much of the apparatus that we already have.

Respectfully submitted,

W. PADDOCK,
Horticulturist and Botanist.

REPORT OF DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY.

To the State Board of Agriculture:

Gentlemen—I have the honor to present herewith the annual report of the Department of Zoology and Entomology for the year 1904:

INSTRUCTION.

Aside from the preparatory classes, the work of instruction in this department is confined to the courses in Agriculture, Horticulture, Veterinary Science, and Domestic Science. The subjects taught are as follows: To the preparatory students, Elementary Physiology; to the sophomores, Advanced Physiology for two terms, Zoology one term, and Entomology one term; to the juniors, Comparative Anatomy, Entomology and Animal Parasites; to the seniors, Embryology, Histology, Entomology, and Evolution of Animals.

The work of instruction has been divided between the first assistant, Mr. S. A. Johnson, and the writer. At the June meeting of the State Board of Agriculture, Mr. C. R. Jones was granted a scholarship in this department, but before the time came for him to begin work he was offered a better paying position by the Bureau of Entomology of the Department of Agriculture, so this department has not had his services.

Mr. L. E. Burnett, who was employed as taxidermist in this department, died last May, and his place has not been filled, so that additions to the museum have almost entirely ceased. The relatives of Mr. Burnett allowed most of the specimens of birds and mammals belonging to the deceased to remain in the College museum, and they also gave the department the tools that Mr. Burnett used in his work.

One year ago the writer was appointed Expert in Charge of Exhibit in Economic Entomology at the Louisiana Purchase Exposition, which has necessitated the expenditure of a considerable time and energy outside of the regular college work.

NEEDS OF THE DEPARTMENT.

For years the department has been in crowded quarters, and its work has been rendered inconvenient, and, to a considerable extent, inefficient, in consequence of not having suitable rooms for class and laboratory work and for the College museum.

Because of raising the grade of our college work, and the addition of new subjects to the course of instruction, and be-

cause this department has been running very low on equipment for several years, it is quite important that it should be dealt with as liberally as possible for a year or two, that it may be creditably equipped for the work of instruction and investigation that it has in hand, and that its work may compare favorably with the work done in similar institutions in other states. The subjects that are assigned to this department can not be properly taught without the appliances that are employed in all first-class institutions. We can better get along with crowded and inconvenient quarters than with inadequate equipment. I very much hope that $1,000, at least, can be allowed the Department of Zoology and Entomology during the next twelve months for equipment alone.

The department also needs another assistant, some one who could do the work of a taxidermist and act as curator of the museum during the winter season, and as general field assistant during the summer season. Such a person could probably be secured for about $800 a year. An invoice of the property in possession of the department is attached hereto.

Very respectfully submitted,

C. P. GILLETTE.

Ft. Collins, Colo., Dec. 3, 1904.

REPORT OF THE DEPARTMENT OF CHEMISTRY AND GEOLOGY.

Fort Collins, Colo., December 7, 1904.

Dr. B. O. Aylesworth,
President of the State Agricultural College,
Fort Collins, Colo.

Sir—There have been no changes in the work in chemistry during the past two years, except such as have been rendered necessary by changes in other departments. Such changes as have been made have changed the work required of the students in no material manner. The changes in the courses of study in the College have necessitated the placing of the chemistry in the junior, instead of the senior year, but the amount of chemistry offered and required has not been diminished, except in some departments, which will be specified, I suppose, in the detailed reports of the respective departments.

The course in chemistry at the present time has been reduced to the minimum, which seems admissible in an institution of our grade and character. It, however, does not seem feasible to increase it, though it would be pleasing to me were we able to do so.

The course at the present time is, considering the advancement made in this branch of study within the past few years, really very elementary, and so limited in its scope that it is scarcely commensurate with the work aimed at by the institution or the position that the Agricultural College occupies in the educational work of the State.

I have not suggested the establishment of a special course in chemistry because, in my judgment, it could not be pursued by the students of our classes except at a sacrifice of time and energy which can be more advantageously expended upon subjects already offered in other departments, and which contribute more directly to the broadening of their culture, and, perhaps, even more to their improvement, both as individuals and as citizens, and which breadth of culture is a prerequisite to their success in chemistry. Were the conditions favorable, it would be very agreeable to me to have a course in chemistry extending beyond our present course by about two years. I regret to say that in my judgment it does not seem advisable at this time to introduce any more chemistry into the course. There is a little optional work offered at the present time, but it has just been introduced into the course, and it yet remains to be seen whether the systematic work now included in the course is sufficient to give the necessary

foundation for such advanced work as is contemplated in the elective work presented.

The class work has followed the prescribed course without any changes whatever, and has been kept up to the full requirements of the catalogue. We have tried to push the laboratory work beyond its present limits, but have found it practically impossible to do so in the time allotted to this branch of work, which really seems to be as much as the requirements of the other departments permit.

During the past and present terms it has been necessary to have two instructors in the laboratory to properly wait upon and instruct the class. This, of course, curtails, almost stops, the work of the department in other directions. The result of this will not be apparent in the publications of the department for about two years, but the investigations now in hand can not be prosecuted with that consecutiveness and breadth which is required for the attainment of commendable results, which, under the best conditions, are accomplished only at a large cost of time and effort. In order to accomplish a little in our experimental work which shall be of more than passing interest and perhaps of some permanent value, it seems necessary to do a very large amount of work, a good percentage of which may in the end prove to be of comparatively little value, and yet it is necessary to do it if we wish to maintain the character of our department and to accomplish some good.

Mr. Bishopp left us last July to accept a position as professor of chemistry in another school. His place has not been filled by the appointment of another owing to our appreciation of the questions of finance with which the Board has been faced. Heretofore I have preferred to take some of our own men and train them to do our lines of work. As a rule this works well and results in their desiring to go elsewhere to round out their education in these lines. It is a practice, however, which I think unwise to follow too continuously. I am not satisfied that it is either more or less expensive in either time or salary than to obtain persons from other institutions, but with increasing classes and important lines of investigation which can be taken up, we need the help of another man in the department.

At your last meeting, June, Mr. Douglass appeared before you to present his request for an increase of salary to $900 per annum. I made no mention of the matter in my semi-annual report, not because I was in any way opposed to his receiving an increase, or because of doubt as to his meriting it, but because I knew the time to be inopportune. Mr. Douglass was fully advised as to my position in the matter, and asked my consent to present his request directly to the Board, which I readily gave. Mr. Douglass is an earnest, faithful and conscientious assistant, in every way deserving of the increase in salary for which he asked, and which I recommend be granted to him.

The building and property under my charge are in good condition, and there are no alterations or improvements desired which require special mention in this report.

I have no request to make pertaining to supplies. The only thing which would facilitate our work is a typewriter, especially one which is provided with chemical symbols. There is such a typewriter on the market advertised at $100 retail.

Respectfully submitted,

(Signed) WM. P. HEADDEN.

ANNUAL REPORT DEPARTMENT OF ENGINEERING AND PHYSICS, 1904.

To the Executive Committee,
State Board of Agriculture:

Gentlemen—I have the honor to submit the following report of the work for the Department of Irrigation Engineering for the past year:

The previous work of this department and the work of the Experiment Station carried on by the Irrigation Engineer along lines directly associated with the fundamental problems of the agriculture of the State, have made the work of great importance in the attacks which have been made upon the right to irrigate in Colorado. Accordingly, when the request to take up the work as State Engineer of this State came in 1903, and the matter was submitted to you for your consideration, it was deemed more important in your judgment for me to take up that work under leave of absence, and that the possible value to the agricultural interests of the State would justify the temporary sacrifice of some of the interests of the department.

Consequently, during the past year I have been able to give comparatively little time to the direct work of the academic side of this work, but have been able to give more or less continual supervision, and to direct the character and scope of the work.

With telephone connecting the offices at Denver and Fort Collins, direct communication can be had at almost any time, and this has helped materially during the absences which have been necessary. With the aid of able assistants, the work of teaching has been carried on on the plans I outlined, and covering the scope and character of the instruction planned in the course. A more detailed reference will be given to the work of these assistants in the course of the report.

NEEDS OF THE DEPARTMENT.

The first and most pressing need of the department is room. With the growth of the department and the increase in its work, the building has been long outgrown. This need in the department has been recognized by you for some years, and efforts have been made to procure additional room. It has been a keen disappointment that the appropriation provided for by the last Legislature was unavailable and that the work began on the proposed building had to cease before the foundation was completed.

The needs, however, are more pressing than ever. The rooms are crowded with apparatus and material which is ineffective

because of lack of room, and can not be effective without an increase of space for laboratory, class room and work of investigation. While the work of the department has been adapted somewhat to the conditions by doing as much work of investigation out doors in the field as possible, the room is still so much below the actual needs as to constantly keep us reminded of the wasteful loss of time and effort which it causes.

The work of the Experiment Station is so much hampered in the office, and what is more important, the investigations in irrigation are resticted, and the office work of reduction, which is often the most important part of the whole work, is exceedingly hampered by the impossibility of an orderly arrangement of data. In the station work a large amount of very valuable data has been acquired during the past 16 years, and it is of vast importance in many respects. It has been the basis in the defense in the celebrated Elephant Butte case, which was indirectly an attack upon the right of irrigation in Colorado. It has also been the foundation upon which the defense in the Kansas-Colorado suit now pending is based.

Aside from the fact that this data could not be replaced if lost, is the fact that it has been of material importance to the State as a whole. The new building proposed was to have ample fire-proof vaults for the preservation of such data, and the need of such safe place of depositing it is very great. There is the constant apprehension of the possibility of losing the work of 16 years, and the knowledge that the loss of this data would be irreparable, and that such data could not possibly be replaced.

I mention the above as what is economically perhaps the greatest need for additional room, only because of the value involved could it be considered as secondary to the interests of the Department of Irrigation Engineering. It is not necessarily a function of that work, but having been under the same direction, the work shaded from one into the other, and the building serving both purposes it is proper to mention it in this report, and to emphasize the possible loss that would result in case of fire under the present conditions.

In the work of teaching, the disadvantages are many. From one to two classes per day at the time when I took charge of the department, without field work, without assistants, and with almost no apparatus, the department now has from eight to twelve or more classes per day in forenoons, and from three to eight in laboratory and field work for two-hour periods in the afternoon. The need for class rooms is therefore far in excess of the room available. It is often necessary to take classes to remote parts of the grounds. Aside from the inconvenience, is the more important loss which comes from the fact that the class is remote from the instruments, apparatus, charts and diagrams which are stored in the building of the department.

The laboratory for the classes in physics has never been suitable for satisfactory work. It is in the basement, poorly lighted and so small that it requires a relatively large amount of supervision. The effect of poor laboratory facilities is shown in the character of the work. The hydraulic laboratory which was started some years ago has had to be given up and the room devoted to the storage of material. The material which we already have and the activities would require at once a building as large as has been planned and as was provided for by the last Legislature. Some of the most valuable work of the department could be done with a suitable hydraulic laboratory, and while the lack of such laboratory has been overcome to some extent by the facilities offered by the canals and reservoirs of the State, yet this causes a change in the character of the work, and makes it necessary to take up a different class of questions. Some of those which now arise are questions which need careful laboratory investigation, and where the most valuable part of the work done will be by laboratory methods.

IRRIGATION ENGINEERING.

The work in this College is the first work along the line of irrigation engineering done in this country. The title of the department was originally physics and engineering. In 1890 it was changed to irrigation engineering, and a course established by action of the Board at that time. This was the first course of the kind. Not only did the work have to be outlined, but also a great deal of the instruction had to be provided without the aid of text books. It has been our attempt to use the facilities which we had to the best advantage, and to qualify our young men so far as facilities at our disposal would permit, so that they would be both useful citizens and qualified to earn their own way. Realizing the limitations, as well as the importance of the work, we have given more attention to some of the problems of hydraulics than to the general questions of engineering.

An examination of the list of graduates from this department since 1892 will show the degree of success that has been attained. I feel still more strongly the need for such training for the best development of the State, and that such work can never be of more importance than at the present time, when our irrigation laws and customs are taking form, and when the need for young men, completely or partially trained, is felt as it never will be again. There is opportunity in this line for young men to be of material value in the development of the State, and there is a call for them not only in this State, but in all other irrigated states of the West. Consequently, I feel that the conditions are more promising than ever before, and better justify the choice of such work on the part of young men, and make it more desirable for a Board like yourselves to anticipate the needs of the agriculture of the State in preparation for the future.

In addition to the training in the physical application of water, there should be given, what at present is doubtless more important to the agriculture of the State, and that is the training of a class of young men who may be qualified for the responsible duties of the administration of water. The conditions in the past have been such that I have discouraged, rather than encouraged, them to look for employment as water commissioners. An occupation where continuity of service and compensation do not depend upon faithfulness of service and qualification, is demoralizing to young men, and I have discouraged their consideration of such work. The indications are at present that a change is likely to occur, and with the increased value of water to the agriculture of the State, there will doubtless be a development which will require qualified young men, and where the conditions will be such as to justify a young man in preparing himself for that work. With the present stage of development I firmly believe that the greatest value to the agriculture of the State may be along that line for the present. The value of a cubic foot of water per second may now be considered as $30 per day, and, consequently, based solely on the economical considerations of agriculture, and as the possibilities of extravagance are exceedingly great, by the better distribution of water in the different water districts of the State, the increased production may be very large, and the training of our young men along this line will give the greatest immediate returns. The improvement in use by farmers requires the change in the practice of individuals, and, necessarily, will be relatively slow process; so, while the improvement in the practice of individuals is of great importance, it is one slower in its results, and will show much less speedily than an improvement in distribution.

In the work in civil and irrigation engineering we have felt that the limitations in training made it best for us to emphasize the training in hydraulics and irrigation engineering rather than in the technical side of civil engineering. The conditions existing in the State have made such training of greater value and qualified our young men to take part in the work of the State. An examination of the list of our graduates will show what they have done in this respect. We have been almost the only institution that has qualified the young men even partially. The possibilities are such that it is extremely desirable to better prepare them, and I feel that we can and ought, with better facilities, to turn out young men immediately available for much of the important work of the State that can be foreseen to be necessary.

ASSISTANTS.

The department has been fortunate in having capable assistants. In 1903 Prof. W. J. Myers was Assistant Professor of Engineering. Professor Myers had formerly been connected with the Experiment Station, and subsequently was Professor of Math-

ematics in the College. He was able to come to us during last year. The work was somewhat interrupted in the spring by calls to some work in the East, and by some work which he did on the Kansas-Colorado case. Professor Myers resigned last June, to give his entire attention to some investigations in connection with the Kansas-Colorado suit, and also to take up work as special expert for the United States Census, in which he is at present employed.

With the increase of work in the spring term, Prof. G. N. Houston was engaged to assist, and upon the resignation of Professor Myers in June, he was appointed as Assistant Professor, and has held the position since that time. He was in immediate charge of the field encampment which for a number of years has been an essential part of the course.

During 1903, Mr. S. L. Boothroyd was Assistant in Physics. For a part of the summer he did some special work for the Experiment Station, and for the United States Department of Agriculture. Early in the fall, a few weeks after the opening of the fall term, he received an appointment at Cornell University, Ithaca, New York, and resigned his position with us. This came at an awkward time, and for a period of some two weeks some of the classes were without instruction. By that time arrangements had been made with Prof. J. E. Bonebright, formerly of Idaho University, and he has since been in charge of the classes in physics.

The arrangement with Mr. Bonebright at present is limited to January 1st. It must be determined whether this arrangement shall be continued for the remainder of the school year, or whether other arrangements should be made. One cause for the present arrangements was the fact that arrangements were partially made with another young man, and it was found, after arrangements had been almost completed, that his Board of Control would not release him until the Christmas holidays. That arrangement is still pending, and has not been completed. It, therefore, is a question whether it is desirable to complete that arrangement, or to engage Mr. Bonebright to continue to the end of the school year.

In the spring, Mr. Lamb helped Mr. Boothroyd in the laboratory instruction in physics. Mr. Lamb had been helping in the Experiment Station for a part of the time. He subsequently entered the work of the United States Geological Survey and left the department short-handed in that work.

Mr. R. L. Parshall, of the graduating class, has been acting as assistant during the fall term, and upon him has fallen a considerable portion of the laboratory instruction in physics under the supervision of Mr. Bonebright.

The assistants in the Experiment Station are not officially a part of the Department of Engineering, although under the same head.

The work of the above assistants has, as a whole, been very satisfactory, and the success of the work of the department is very largely due to them.

FIELD CAMP.

The class in Civil Engineering were taken for their annual field encampment in the latter part of August. The trip was again made to Estes Park, which, as a whole, offers more of the desirable conditions for field work than any other region that is within our reach. It affords a great variety of topographical conditions, running streams for hydraulic work, communication by telephone and by mail, and stores for the purchase of supplies.

The work this year was the survey of a reservoir. The class ran transit and level lines necessary to make a filing, and each member of the class has been expected to prepare complete maps for filing. This work was immediately directed in the field by Professor Houston and Mr. Parshall.

THE NEEDS OF THE DEPARTMENT.

The first and greatest need, as before mentioned, is a building such as has already been planned, the erection of which we had hoped for for a number of years. The equipment which is needed is entirely secondary to the above need. With the limitation in room every material addition to the present equipment tends to hamper the work because it decreases the available space, hence the additions of equipment are mostly small and rather along the line of current supplies.

I would call attention to the fact that during the next scholastic year we shall need to provide for additional classes. This will require some additional school room and also more instruction. Because of the change made in the College course a few years ago, one class was dropped out. A year ago we had no junior class, and this year we have no senior class. That is, last year we had freshman, sophomore and senior classes, the present year we are giving instruction to freshman, sophomore and junior classes, and next year we will have freshman, sophomore, junior and senior classes in addition to the sub-freshman classes. The additional instruction required will call for the services of another instructor for a part, if not all the time, and will also make necessary a corresponding number of class rooms. The matter of another instructor will not need to be settled now. It can be brought up at the June meeting of the Board.

DIVISION OF ENGINEERING.

Professor L. G. Carpenter:

Dear Sir—I would submit the following report of my work in this department from March 1, 1904, to date:

During the Spring Term I took charge of the following classes: Freshmen in Surveying, sophomores in Irrigation Engineering, and the freshmen, sophomores and seniors in Field Work.

There were twenty-four freshmen in the class in Surveying. This included all students taking the Engineering courses. The greater part of Raymond's Text Book on Surveying was covered in the class room, and the use of the chain, tape, compass and level in elementary problems in the field.

In Irrigation Engineering Wilson's Text Book was used. Eight sophomores reported for this class. In field work the sophomores, a class of fourteen, ran a preliminary and location survey for about two miles of railroad, it being the intention to supplement in this way the theoretical course in Railroad Engineering given in the winter term.

The senior class last year, being the last class to graduate under the old three year schedule, would correspond in standing to the present junior class. The field work of this class of six consisted of one half term in practical work with surveying instruments and one half in gauging ditches in the vicinity.

THE FIELD CAMP.

We left Fort Collins on the morning of August 25, with our camp equipment packed in three wagons, and arrived in Estes Park on Saturday morning, August 27.

Our party consisted of nine juniors, seven sophomores, Mr. Parshall (my assistant), a teamster, a cook, and myself, twenty in all.

The National Guard of Colorado kindly loaned us one fly tent, two officers' tents and one Sibley tent, which, together with my own 10x16 wall tent with fly and small tents of this department, furnished comfortable quarters this year.

The work consisted of the survey of a reservoir site. The proposed reservoir covered about 200 acres, is about one mile long, one-half mile wide in the widest part, with a maximum depth of thirty feet. The work included a traverse on the high water line, which checked within 1 in 3,500, and the obtaining of the topography by means of parallel sections run across the site on which

every five-foot contour was located. Where this failed to show the topography sufficiently it was supplemented by the transit and stadia method, based on a system of triangulation points. The traverse was worked up and a field map made.

Returning, we arrived at Fort Collins in the afternoon of September 9.

The sophomores are now, under the winter term course in Draughting, making a complete map of the site such as is required for filing in the State Engineer's office.

Before leaving this matter I would say that in order to properly do the work and maintain the good health of the party, the following additions to the camp equipment are imperative:

One officer's tent, 10x16-4′ wall with fly, 10 oz. duck.

Three Sibley tents, United States National Guard type.

One officer's tent, 10x12-4′ wall, United States National Guard type.

The present rope ridge tent and the pyramid tents can be used advantageously for store tents, cook tent, etc., as they were this year.

There should also be one light steel range.

FALL TERM.

During the fall term I have had the classes in Seminar, Higher Surveying, Mechanics of Materials, Strength of Materials, Laboratory and Field Work.

Nine sophomores reported for Higher Surveying. In this course we reviewed Raymond's Text Book and supplemented it by the descriptive matter in Pence & Ketchum's Field Manual. This occupied a little more than one-half of the term, and was followed by a course of lectures on the elementary astronomical conceptions and the mathematical calculations involved in the determination of time, latitude and azimuth with the common engineer's transit.

The field work of the sophomores in the afternoon followed in general the problems in Pence & Ketchum's Field Book under "The Transit and Level" with additional observations for time, latitude and azimuth.

Ten juniors took the course in Mechanics of Materials. Merriman's Text Book was used, the work covering the first six chapters. Owing to the fact that the testing machine is in need of repair, that it has no proper registering apparatus, and that the course was crowded into the first half of the term when the students had very little conception of the subject, the course in Strength of Materials Laboratory did not prove very satisfactory.

SEMINAR.

During the fall term two hours per week were given to Seminar by the juniors. Each man was required to prepare a paper on some important engineering topic and read it before the class, after which a general discussion took place. Under this course such matters as the work of the U. S. Reclamation Service and the construction of the Moffat road were reviewed and discussed.

WINTER TERM.

The sophomores are using Webb's Text Book in the course in Railroad Engineering as usual.

The course in Materials of Construction is given for the first time this year. It occupies the first half of this term, and covers part II in Johnson's Text Book.

The sophomore course in Draughting, as I said before, consists at present of working up and platting the notes taken on the field trip. Owing to the small quarters this class reports in two sections on alternate days, each four hours, instead of two hours per day, as scheduled. With this arrangement it is impossible to put in the full time, as no satisfactory draughting can be done after four o'clock p. m.

The arrangements for junior seminar this term are as follows: Each member of the class is to prepare a paper on an assigned subject, and read it before the engineering society. It is to be neatly written on manuscript paper, and handed to me at least three days before reading, for correction and grading.

Respectfully,

G. N. HOUSTON.

Fort Collins, Colorado, December 7, 1904.

DIVISION OF PHYSICS.

To Professor L. G. Carpenter:

Dear Sir: During the fall term of this year, 1904, the Division of Physics had in the second sub-freshman class 59 students in three sections in recitation work, and fifty students in four divisions in the laboratory work. The students in the second sub-freshman class were registered for two hours laboratory work each day, but although the laboratory was open every afternoon up to 5:30, it is impossible with four sections to give the students more than two hours laboratory work on alternate days. To make up for this, quizzes and additional drill work were provided for those students who were not in the laboratory. This arrangement of the divisions for the laboratory work is somewhat a disadvantage to the student, since he is able to attend but four hours one week and six the next. The size of the laboratory would have to be doubled to accommodate all the students with two hours laboratory work each day. Laboratory room is very badly needed.

There were 19 students registered in Mechanics for the fall term in the sophomore class. This class during the term covered the first 126 pages of Wood's Mechanics. The class was very unfortunate in having no instructor during the first month of the term, September. I began the work here the first of October.

The fall term in the second sub-freshman Physics covered the first 140 pages of Carhart & Chute High School Physics. This included mechanics of solids, and mechanics of fluids. In the laboratory the students performed from fifteen to twenty-five experiments, kept note books and passed examination on the experiments performed.

During the winter term the second sub-freshman class will be expected to reach "Electricity and Magnetism" in Carhart & Chute High School Physics. This class will probably finish, on an average, about twenty more experiments in the laboratory during the winter term.

The divisions of students in the recitation and laboratory work of the second sub-freshman class are the same as during the fall term. The number of students for the winter term is practically the same.

The class in Mechanics for the winter term consists of but fourteen students, all of whom are taking the Civil Engineering course. This class will be able to cover the remaining portion of the text in Wood's Mechanics during the winter term.

Respectfully submitted,

December 9, 1904. J. E. BONEBRIGHT.

REPORT OF DEPARTMENT OF MECHANICAL ENGINEERING.

To the State Board of Agriculture:

Gentlemen: I have the honor to submit herewith the annual report of the Department of Mechanical Engineering. The work of the department has been carried by classes as follows:

FIRST SUB-FRESHMAN CLASS.

The members of the sub-freshman class come to the department for shop work only, and they have been given instruction in the wood-working room and blacksmith shop.

SECOND SUB-FRESHMAN CLASS.

Those who begin their work in the institution in the second sub-freshman year are given instruction in the wood-working room and blacksmith shop, and those who have reported during the past year have been given such instruction.

A number of irregular and special students have taken the work with the first and second sub-freshmen.

FRESHMAN CLASS.

The freshmen have received instruction in instrumental drawing embracing 110 geometrical problems, and 50 problems in orthographic and isometric projections.

They have received instruction in lettering for mechanical drawings. Numerous drawings from copies from acknowledged authorities in engineering work have been made. The members of this class have also received instruction in tracing and blue-print work.

There have been fifty members in the class in Carpentry and Joinery and the work has consisted of a preparation, by means of a text book, for the lecture work which concludes the study.

The text book work is principally on wood-working tools, their care and use, and also on the handling of timber from the tree through the seasoning yard or kiln; later the class was given a course of lectures on contractor's work, and the use of the steel square.

They have completed work in wood-turning and pattern work extending over one and one-half terms.

SOPHOMORE CLASS.

The students in this class have received instructions in the sketching of machine parts, and during one term they made designs for screw threads, bolts, nuts, cap screws, etc. Another term was devoted to elementary machine design.

Text book work and lectures upon machine shop appliances were taken up for one term.

JUNIOR CLASS.

The members of the junior class taking the work of the past fall term have completed, in the department, the study of the elements of mechanism.

On account of the change in the course of study of the College, and being yet in the transition period from the old course to the new, there was no regular junior class last winter and spring.

SENIOR CLASS.

This year there is no regular senior class.

Last year's students in the regular senior class completed the study of the principles of mechanism, the study of steam boilers, steam engines and steam engine design.

The members of the Senior Class also did a good deal of work in the mechanical engineering laboratory.

Great interest is taken in this laboratory work, and I desire very much to see it elaborated and extended; this, of course, will require the expenditure of some money, but it certainly will be of lasting benefit to the young men about to leave the institution, as it affords an opportunity for original investigation and experimental work.

Before any more apparatus is put in this room the portion of the stone floor not completed should be attended to, as it is in a very disagreeable condition when work is being carried on.

RECOMMENDATIONS.

I would respectfully ask your attention to a few things about the department that I think should be looked after at an early date.

The completion of the stone floor mentioned above is one thing.

When the college buildings were overhauled, repaired and painted, a few years ago, the Mechanical Engineering building was not repaired or painted; it needs attention now, as the roof leaks in several places, the paint is coming off the woodwork in many places.

One of the most urgent needs of the department at the present time is a well equipped wash room for the students. The pres-

ent wash room is one provided twenty-one years ago, and is designed to accommodate six students at a time.

There are now from one hundred and fifty to two hundred students in the shops, and about half of these are liberated from their tasks at a time, and it is impossible to properly accommodate them.

My plan for remedying this is to put a glass roof over the open court between the two portions of the building, moving the foundry supplies to a place under a good sized wooden shed, which could be built at the west of the foundry. This would give a place for a good wash room, and it might be provided with a cement floor, permitting it to be washed clean, and drain into the sewer which now passes under the open court.

There would be ample room for wash sinks and coat lockers. I should be much pleased to have you look into this matter at this Board meeting. I should like to have a moderate sized skylight put on the north slope of the blacksmith shop roof, to assist in giving better light in the middle of the room.

Since more studies have been added to the Mechanical Engineering course, there will be several classes, in different subjects, requiring class rooms for their recitations at the same hour, and, as we have but one recitation room in the department, I would like to have another partitioned off the end of the machine room as soon as it can be arranged, and some desks provided.

I would respectfully request that an experienced carpenter be at once put in as assistant instructor in the woodworking room, and employed continuously; this would prove a very satisfactory arrangement, and enable us to better attend to the work which we are continually doing for the various departments of the College, and afford much needed assistance to the man in charge of the wood room, who now has ninety students in wood work, and sometimes considerably more than that number.

Respectfully submitted,

J. W. LAWRENCE,
Professor Mechanical Engineering.

REPORT OF THE DEPARTMENT OF ELECTRICAL ENGINEERING.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit the second annual report of the Department of Electrical Engineering.

The first year for the department was a successful one. The sophomore work in "Elements of Electrical Engineering" was completed by the whole class in a very satisfactory manner. This work consisted of studying the principles of, and the laws governing, electric and magnetic circuits; the methods of measuring the several electric and magnetic quantities; the use of these laws and principles in the development of the dynamo, motor and transformer, and an investigation of the fundamental principles of electricity and magnetism in their application to the arts and sciences.

The work for the year of 1904-05 has progressed nicely. Laboratory work was given for the first time during the fall term. This work, as far as it could be carried, with the small amount of apparatus in the laboratory, was satisfactory.

The number of students registered for the work in Electrical Engineering, so far this year, greatly exceeds the number of last year. There are now forty-eight students of the College who are registered for this work. Of this number fourteen are in the four collegiate years, and the remaining number are in the preparatory department. The total number registered for Electrical Engineering is, therefore, over 13 per cent. of the total registration of the College.

In connection with my work at the College, the American Institute of Electrical Engineers, through its Secretary, has asked me to organize a students' branch of the institute among my students. This invitation came without any solicitation on my part, and should be considered a compliment of no mean degree. In compliance with this request the branch organization is about perfected. The associations which the students will have, through the agency of this organization, with the electrical engineers of this country will be of the greatest benefit to them.

During the summer months, by direction of the Board, I have had the electric wiring in the College buildings overhauled and put in first-class condition. As far as possible the wiring at the College is now in accord with the "National Electric Code" of the National Board of Fire Underwriters. The expense attending these changes is as follows:

Main building	$ 148.00	
Civil Engineering building	53.50	
Domestic Science building	33.00	
Horticultural building	34.00	
Mechanical Engineering building	141.00	
Commercial building	38.75	
Horticultural barns	2.25	
Agricultural building	60.00	
Farm house	1.35	
Farm barns	3.80	
Chemical laboratory	27.30	
Line and transformers	178.83	
		$ 721.78

The wires are now supported on insulators well away from iron pipes and braces, and from wooden partitions and floors. Each building has been divided into two or more circuits, thereby reducing the number of lamps on each circuit. All transformers have been taken from the building and placed on substantial poles. Cutouts, which were generally placed in dark attics and in other out of the way places, have been installed in distributing boxes where they can be easily inspected.

Since my last report I have purchased for the electrical laboratory apparatus amounting to $323.65, and for the lecture rooms apparatus amounting to $123.45. The laboratory apparatus consists of Weston volt meters and ammeters, resistance boxes, bridges, shunts, condensers, galvonometers, standard resistances and cells and laboratory keys and switches. The amount purchased was just sufficient to carry on my work up to the holiday vacation.

The importance of laboratory work in connection with the course in Electrical Engineering can not be overestimated. An engineering education should be just as practical as possible consistent with a thorough understanding of fundamental principles. The laboratory is absolutely essential to give the students a working knowledge of these fundamental principles. For these reasons it is my desire to build up a laboratory commensurate with the importance of the work and the needs of the students.

I have maintained a supply department in which are kept on hand lamps, lamp cord, switches, sockets, fuse wire, batteries and other material necessary to keep the lighting and bell systems in working order. These supplies are bought at wholesale prices, thereby saving the College considerable money. An inventory of the supplies now on hand is submitted.

I would respectfully call the attention of the Board to the needs of the department.

That the junior laboratory work may be carried on to completion, additional apparatus to the amount of about $1,000 should be obtained. A list accompanying this report gives this apparatus in detail. The apparatus on this list should be ordered as soon as possible, as a portion of it will be imported, duty free, and requires a long time to arrive.

I would recommend that the city water be piped into the Electrical Engineering building. At present there is no adequate means provided to guard against fire. The building is isolated from the other college buildings, and the danger from fire is, therefore, apparently a minimum. But the building is being heated with stoves, which increases the fire hazard. Water is now carried from quite a distance for use in the department.

Since the department was opened I have been using borrowed furniture in the office, such as desk, chairs, book shelves and typewriter desk. The rapidly growing electrical library requires shelf room. I would respectfully request that shelving be built in the office, that the office be provided with a roll top desk and a typewriter desk.

No provision has been made to protect the apparatus in the laboratory from the dust and from being handled by curious visitors. I would, therefore, request that a case be built in which the apparatus can be properly kept. The several pieces of fine and expensive apparatus will soon become injured by exposure to the dust, and by improper handling, and in a short time will need to be replaced with new apparatus. If they are properly taken care of they will last an indefinite time.

Respectfully submitted,

S. D. CRAIN,
Professor of Electrical Engineering.

Fort Collins, Colo., November 30, 1904.

REPORT OF THE DEPARTMENT OF DOMESTIC SCIENCE.

To the State Board of Agriculture:

Gentlemen—The Department of Domestic Science begs leave to submit the following report:

Since the annual meeting of the Board in December of last year the Department of Domestic Science has prospered, and here, as in the entire College, a general improvement by all the students has characterized the progress of the year.

The normal course in domestic science still attracts much attention, but on account of the prerequisites for entrance and the heavy work in the sciences, many are unable to take advantage of its opportunities, although they desire to do so. However, it is an excellent course for those who are prepared for it, and have time and money to devote two years to the varied and attractive subjects which it offers. When possible all classes have received instruction in accordance with the outline in the catalogue. As has been stated before, the building is inadequate to meet the demands of the growing department.

It has been necessary for several years for one or two classes to recite in class rooms of other buildings. This is very inconvenient, because the manual work necessitates the moving of equipment. With the excellent assistant instructors now in the department, the efficiency in all these lines of work would be materially increased if there were more room.

Hoping that your honorable body may be able to devise ways and means whereby this need can be met, I remain,

Most respectfully,

THEODOSIA G. AMMONS.

Fort Collins, Colo., December 1, 1904.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

To the Honorable State Board of Agriculture:

Gentlemen—The following is respectfully submitted as the annual report of the work done in the Department of Mathematics:

During the year this department has given instruction to twenty-seven classes in mathematics. The work as outlined by the catalogue has been followed without a break and the following subjects have been taught: Arithmetic, elementary algebra, plane and solid geometry, trigonometry, descriptive geometry, college algebra, analytical geometry, and differential and integral calculus.

As a whole, the work of the students in this department has been good. There have been some failures, of course. This is to be expected. Some of these failures are the result of indifference and laziness on the part of the student, while some are due to a lack of preparation in the public schools.

In mathematics, more than in any other subject, one branch depends upon another, and when a student comes to us for college algebra, knowing practically nothing about elementary algebra, he finds himself beyond his depth, and unable to do the work. The only remedy is to send him to a lower class. This is often humiliating to him, but how much better to require him to lay a good foundation upon which to build than to allow him to continue in the higher work where he must fail and fail again until he at last becomes discouraged, and leaves College disgusted, sometimes with himself, but more often with mathematics.

I have, therefore, insisted upon making the work for the lower classes rigorous, and after thoroughly mastering the lower branches the students have very little trouble with the advanced work.

I believe in the new idea of "Laboratory Mathematics," and ever since I have been connected with the department we have invited and urged students to come to us in the afternoon, when we are not busy with class work, and get suggestions and help. This work is sometimes tiresome, but it has borne good fruit.

The following is a detailed account of the work for the year:

FIRST SUB-FRESHMAN CLASS.

Throughout the winter term of 1903 and 1904 this class continued the study of elementary algebra, begun the term before. The class was divided into two sections, and was made up of

eighty-two students. The work done during the term covered the subjects of factoring, highest common factor, lowest common multiple, fractions, and a start in simple simultaneous equations.

The spring term found sixty-four students enrolled. Those not able to do the work were dropped into an arithmetic class, and given a thorough review in this subject. The work of this term comprised simple simultaneous equations, involution, evolution, theory of exponents, and radical expressions.

When College opened again this fall a new class began the study of elementary algebra, and has been duly initiated into the mysteries of addition, subtraction, multiplication and division of algebraic quantities. The class this term numbered one hundred and twenty-eight students.

SECOND SUB-FRESHMAN CLASS.

The sixty-nine students of this class during the winter term continued the work in geometry begun the term before, and during the term they finished the plane geometry as given in Wentworth's text.

The spring term found sixty-eight students in this class, and their work in solid geometry covered the ground usually given in this work.

This fall a new class of fifty-nine students began the study of geometry. They have covered the work of books I and II of Wentworth's Plane and Solid Geometry.

FRESHMAN CLASS.

The mathematical work scheduled for the freshman during the winter term is trigonometry. There were thirty-seven students in this class, and the subject of plane and spherical trigonometry as given in Lyman and Goddard's text was mastered by most of them.

During the spring term the advanced college algebra held the boards, and the class of thirty-two students has as much pure mathematics as most young people can relish, and more than some could stand.

During the present fall term a new freshman class starts in and have just finished their fall term's work in college algebra. It is a good, hard working class of thirty-nine students, and will be a credit to the institution.

SOPHOMORE CLASS.

Students of the Engineering classes continue their mathematical studies during their sophomore year.

The winter term of 1903 and 1904 found twenty students at work on differential calculus. It was a good class, and the members were keen, hard-working young people.

The spring term was spent with the integral calculus, and the work was of the same high order as the work of the previous term.

The fall term just ended finds a class of nineteen young men finishing up analytics. They are good, level-headed boys, not as brilliant as some classes I have had, but far from being a poor class.

During the fall and winter terms the sophomores also take up the study of descriptive geometry. They take up the elementary problems of this subject, and many practical problems are given later. The class last year was a disappointment to me. They seemed to have great difficulty to get hold of the problems properly, and their drawings were poorly done—the first class I ever had that showed these symptoms.

The new class of this year are doing much better than last years' class, and it certainly is a relief, for I never worked with a class of boys as hard as I did with those of last year's class, and the results were anything but satisfactory.

During the winter and spring terms of 1903 and 1904 I had the pleasure of taking a student through some of the higher mathematics. After finishing all the mathematics taught in any of the regular courses, Miss Florence Stuver, the best student in mathematics this College ever knew, asked for more. Together, at odd times, whenever my time would permit, we took up the subjects of spherical trigonometry, solid analytics, determinants, and differential equations. She did all the extra work well, and deserves much credit for it.

I have to report harmony among the teaching force in this department. My assistants are honest, hard-working fellows, and are pounding away in hopes that some time, some day, Dame Fortune may smile upon them with an increase of salary.

In conclusion, I have to thank you, gentlemen, for the kind consideration and courteous treatment I have received at your hands.

Respectfully submitted,

E. B. HOUSE,
Professor of Mathematics.

REPORT OF THE DEPARTMENT OF LITERATURE AND HISTORY.

To the Board of Agriculture:

The past biennium has been a period of growth and progress in the Department of Literature and History. Courses in English and Mediæval History, and in the English Drama, have been added to the curriculum in the sophomore and junior years, and the enrollment, particularly in the lower classes, has been increased.

During the past year this department has found pleasant and commodious quarters in the south class room in the new chapel addition to the main building, and the efficiency of the department has thus been increased.

A commendable movement on the part of students has contributed to the decoration of the new room with art treasures, in which our College has been singularly lacking. The class of 1907, upon completing a course in American Literature, left as their contribution a portrait of Ralph Waldo Emerson, which now adorns the class room wall; the class of 1908 has contributed a bust of Shakespeare, and the class of 1909, upon completing their work in Greek History this fall, added a cast of Greek statuary to further adorn and beautify the class room for the benefit of those who will follow them.

Another forward movement in the interest of the general culture for which this department stands, is the lecture course for college girls, which was offered for the first time during the winter of 1903-1904.

The following list of entertainments was given:

"Some Other Women," Miss Frances Bridges, Chicago, Ill.

"A Day in a Girl's Life," Miss Anna Heileman, State Normal School, Greeley, Colo.

"A Place for Art," Mrs. C. H. Jacobson, Denver, Colo.

"The College Girl," Mrs. W. F. Slocum, Colorado Springs, Colo.

"Musical and Social," C. A. C. Girls.

"What the College Should Do for the Woman," Mrs. Sarah P. Decker, Denver, Colo.

"Rambles in Literary England," Miss Virginia Corbett, Fort Collins, Colo.

To the ladies who came to us from other cities, and contributed so generously of their time and talent for the benefit of

our college girls, we are glad to express our thanks and appreciation.

Another similar course of lectures has been arranged for the coming season, for which the following numbers have already been secured:

"Student Life at Wellesley," Miss Elizabeth Taylor, Minneapolis, Minn.

"An Afternoon of Readings," Miss Nanaruth Taggart, Denver University, Denver, Colo.

"Alumnæ Afternoon," C. A. C. Alumnæ.

"A Question for College Students," Mrs. H. D. Thatcher, Pueblo, Colo.

"The Making of the American Woman," Mrs. J. H. Baker, Boulder, Colo.

"Musicale and Social," C. A. C. Girls.

In addition to the changes and new features already mentioned, the regular work of the department has been carried out as prescribed in the catalogue. In most cases the classes have been large, and good student spirit and interest have been manifested.

The efficiency of the department is still greatly crippled by inadequate library facilities. We need, above all things, larger reading room space in the library, and access to the thousands of volumes stored for lack of shelf space, and to the many volumes of valuable periodicals which are now packed away awaiting funds for binding.

Respectfully submitted,

VIRGINIA H. CORBETT.

Fort Collins, Colo., December 1, 1904.

REPORT OF THE DEPARTMENT OF MILITARY SCIENCE.

To the State Board of Agriculture:

Gentlemen—I have the honor to submit the report of the Department of Military Science and Tactics.

The rosters of the different organizations show an enrollment of two hundred and fifty-eight (258) cadets, who have received instruction in the department during the present College year.

The assignment to the different organizations are as follows:

Staff	3	
Band and field musicians	30	
Company "A"	53	
Company "B"	51	
Company "C"	55	
Company "D"	56	
Recruits unassigned to company	10	
	—	258

The proportion of new students being greater than usual, the preliminary training and individual instruction required has taken considerable time. In this connection a word of commendation is justly due the officers of the battalion, who have worked most faithfully in instructing those under them, and in advancing the work of the department in general. A most lively interest in the welfare of the military organization is displayed, not only by the officers, but as well by the great majority of the cadets.

The work so far in the present College year has covered, in part, the School of the Soldier, Company and Battalion, in close order. It is the plan to perfect the work in close order formation during the present term. The spring term will be devoted to drill in extended order, battle exercises, with occasional ceremonies, such as Battalion Parade, Reviews, Inspections, Escort of Color, etc.

During the fall term officers and non-commissioned officers' school has convened once each week for the purpose of study and recitation. The text book used has been the United States Infantry Drill Regulations, with the lessons and recitations covering the work as it progressed on the drill ground. These schools were very beneficial in enhancing accuracy and uniformity in the instruction given by the different drill masters.

Your Secretary, Mr. Hawley, has provided the department with a complete set of national flags for use on the College flag-staff. These are in every way similar to those in use at all army posts. A detail of three cadets are assigned each week, whose duty it is to raise and lower the flag at the proper times, and to have the care of them. This duty, I find, is enjoyed by the cadets, and is a means of increasing their respect for the nation's flag.

I would recommend that, if the change can be made with no great outlay of money, that the Springfield rifles now in the possession of the College be exchanged for the newer service rifle.

Respectfully submitted,

R. A. MAXFIELD,
Commandant.

Fort Collins, Colo., December 6, 1904.

REPORT OF THE DEPARTMENT OF RHETORIC AND PHILOSOPHY.

The State Board of Agriculture:

Gentlemen—In compliance with the laws of this State, I transmit to your honorable body, through the President of the College, the annual report of the Department of Rhetoric and Philosophy from December 1, 1903, to December 1, 1904.

During the winter term of 1903-1904 there were five regular classes conducted by the department, viz.: the freshman class in college rhetoric, in two divisions, the freshman class in themes, and the first sub-freshman class in elementary rhetoric, in two divisions.

The class in college rhetoric was composed of eighty-two students of freshman and junior commercial rank. Baldwin's *A College Manual of Rhetoric* was followed as a guide, the time being devoted to the work of description and persuasion. A leading part of the work was a series of debates in which every student enrolled for rhetoric took part. These debates were reviewed, criticised and judged by a committee of critic judges selected from the faculty of the College and from the ranks of professional men of the community. Themes were frequently written, and the class showed at all times a most commendable interest. The class in themes numbered forty-seven students of freshman rank. The work was practical, and the English of the class improved noticeably.

The class in Elementary Rhetoric was composed of eighty-seven students, who pursued the subject as presented in the pages of Scott and Denney's *Elementary English Composition*.

As the senior class of last year graduated under the old course of study, as there was, for the same reason, no junior class, the work of the spring term was principally in elementary rhetoric, the students in this study being about eighty in number. They continued the use of Scott and Denney.

During the fall term just closed, I have conducted classes in college rhetoric and elementary rhetoric. There being no senior class, the subject of logic was not taken up.

The class in college rhetoric was composed of sixty-six students of freshman rank. The text book was Baldwin's *A College Manual of Rhetoric*, the titles of exposition and narration being thoroughly covered. As a closing exercise, the students of the class elected a board of editors to whom they submitted for acceptance or rejection manuscript "copy" for a sample display magazine, divided after the manner of magazines in general into

departments, each department being under the charge of a special editor. As this work stirred up so much real effort and produced so many good results, the work done on the articles for this magazine were allowed to stand for the work of the final examination in college rhetoric. This arrangement found ready favor with the whole class, being regarded as eminently fair, and it proved one of the best devices that I have ever used in gaining from the students their best work and endeavors.

The class in Elementary Rhetoric numbered one hundred and twelve students pursuing the study from A. S. Hill's *Beginnings of Rhetoric and Composition*—a new book which is in every way a most decided improvement over any other manual of elementary rhetoric which we have ever used in our classes. A great deal of written work is asked for, and especial emphasis is laid upon diction, spelling and general accuracy in interpretation. As it is perfectly possible to notice from day to day the improvement in the work of the students of this class, their work is naturally pleasing and interesting to the instruction, as all such advancement and progress is growth and improvement.

Respectfully submitted,

EDWARD M. TRABER,
Professor of Rhetoric and Philosophy.

Fort Collins, Colo., December 6, 1904.

REPORT OF THE DEPARTMENT OF CONSTITUTIONAL HISTORY AND IRRIGATION LAW.

To the Honorable the State Board of Agriculture:

Gentlemen—I have the honor to submit herewith my semi-annual report as professor of the Department of Constitutional History and Irrigation Law.

The summer vacation immediately following the date of my last report was spent in an investigation of the irrigation laws of the seven leading irrigation states, as the same especially related to the office of State Engineer, the work being under the direction of Dr. Elwood Mead, Chief of the Bureau of Irrigation Investigation of the Department of Agriculture at Washington. This work proved of great value to me as an instructor, as it enabled me to present to the class in Irrigation Law the latest legislation on this subject, in the form of lectures, the facts contained therein being otherwise unattainable, not yet being in print.

During the fall term I conducted the classes in Commercial Geography, International Law and Irrigation Law, in all of which great interest was manifested by the students. During the present winter term I am conducting classes in Advanced History and in Political Economy. Not a little of the work that has fallen to the share of this department is the coaching of students in the matter of debates and orations. While the task is a pleasant one, it involves during the school year no small amount of time, but I am thoroughly impressed with the belief that no expenditure of time is more profitable or advantageous to the students who engage in these debating and oratorical contests. When once the proper line of investigation is pointed out to them they enter upon it with zeal and enthusiasm. The result is a broadening of the student's intellectual horizon and a toning up of the literary spirit of the entire institution.

I have but one suggestion to make in regard to the work in this department, and that relates to the present inadequate library facilities. The highest success of students in the line of studies committed to this department lies in their ability to consult various authorities in law, history and economics. These facilities are at present almost wholly lacking. The librarian is always prompt, willing and zealous in rendering all possible assistance, both to students and professors, but he can not accomplish the impossible. The library needs room so that students can have the use of tables in consulting the authorities to which they are referred by their instructor. Many of the most valuable

works in history and economics have been issued in recent years, none of which are to be found on the shelves of the library. There are no works on the history, growth and legal development of irrigation institutions in the library. Even the government bulletins on these topics, most of which are extremely valuable, are not in a shape where they can be consulted by students. The library is the real work shop of an educational institution, and its conditions can retard or advance the work of every department. In the especial interest of my own department I invoke for it your kindly attention and fostering care.

Acknowledging the constant courtesy of the President, the faculty and the entire management, I remain,

Very respectfully,

W. R. THOMAS,
Professor Constitutional History and Irrigation Laws.

The State Agricultural College, Fort Collins, Colo., December 10, 1904.

REPORT OF THE COMMERCIAL DEPARTMENT.

To the Honorable the State Board of Agriculture:

Gentlemen—The Commercial Department is taxed to its utmost capacity, both in number of students registered and equipment. Many applicants were unable to register through lack of preparation, for the work of the Junior Commercial class. Two graduates of the College are taking the course. Other graduates have made inquiries about the opportunities offered and would like to undertake the work. A number of students in the regular courses are taking special work in the department. The enrollment does not vary from year to year, since only so many can be accommodated with the present equipment and teaching force. Students in the technical work spend just double the time in practice as compared with most business courses.

Over 75 per cent. of last year's Junior Commercial class returned to complete the senior year and are candidates for graduation. The few who did not return secured lucrative employment.

There were but two failures in the work during the fall term, and in these instances the students are entitled to a re-examination. The students are intent upon their work. Such an evident and eager interest in their studies has never been so manifest. There are no malingners in the Commercial Department. The young men belonginging to the football eleven, it is gratifying to note, are among the best students and stand highest generally.

There has been one withdrawal. This student will return next year and complete the senior work.

Speaking for the students, it would be difficult to find a more earnest and energetic body of students; at all times courteous and industrious, and deporting themselves as young ladies and young gentlemen desirous of accomplishing something.

Respectfully submitted,

LATHROP M. TAYLOR.
CHAS. G. DWYRE, JR.

Fort Collins, Colo., December 1, 1904.

ANNUAL REPORT AND INVENTORY OF THE LIBRARY.

To the State Board of Agriculture.

The following is a condensation of the annual report which is respectfully submitted with reference to the library:

The Board is respectfully referred to the contents of the three previous reports for information and for requests not mentioned in this report.

We have reached our limit of storage room, vacant rooms, hallways and all available space has been used for the most compact box storage. In one room, alone, in the chemistry building, we have a solid cube of boxes (nearly 12 feet) containing about 125 boxes, with nearly 4,000 volumes. In the department libraries we have about 3,000 volumes on open shelves. In the library stackroom and reading room we have nearly 11,000 volumes on open shelves and the rooms are so small and so full that we have to do all our work on the window sills.

There is no building on the college grounds large enough to contain the library, which, at the same time, is possible for that purpose. Only two buildings can be considered in any scheme for housing the library; (1) the *Civil Building*, which is too small, not fire proof and not strong enough, (2) the *Commercial Building*, which is not fire proof and which must be "double decked" (two-story stack) in order to hold the books we are to put into it. We need immediate shelf room for 25,000, besides a reading room and a delivery room.

A steel structure in the *Commercial Building* would cost too much money ($3,500) to put into a building of that kind, yet, because of many advantages (noted), steel is what we ought to have.

Beginning with the last session of the latest Congress we became "a designated depository," and with the help of our congressman-at-large and the Superintendent of Documents we have a valuable document library which we must shelve in order to retain the designation.

An agricultural college ought to have a good working set of the publications (and they are many) of the U. S. Department of Agriculture. We have all the indexes and we ought to try to acquire a respectable set of the documents.

We have not attempted a collection of State or of foreign documents. We have no time and no money which is not absorbed and exhausted before we get to them.

Our collection of experiment station bulletins and reports are better than one usually finds in a library and we have a 25,-000-card catalogue covering the collection. It ought to be bound and shelved where it may be used.

The U. S. government check lists, catalogues and indexes in this library are almost complete, including 15 shelf-feet of printed books and more than 50,000 printed cards. Our index collection is better than our document collection.

Our list of donors and donations include 49 names and 1,318 pieces added to the library records. The list should be printed here, but exceeds the space allotted for this report.

The circulation records are analyzed and discussed with reference to the problem of more room and more help.

The condition and the progress of the catalogue is set forth in detail and the necessity of more cabinets pointed out. Capacity for over 150,000 cards is required for all the catalogues, printed and typewritten. Purchase of A. L. A. and Library of Congress cards is also recommended. The growth and care of the shelflist is included in the discussion of catalogue.

Special requests for catalogue cabinets, agricultural literature (bulletins, etc.), periodical binging (2½ years), back numbers on our periodical "want list," amount to 1,215.

The inventory amounts to $30,802. Amount for books added by purchase, $975.14.

Bound volumes in the College Library.........	16,639	
Duplicates and other bound and unbound......	7,500	
Total		24,139

I take this occasion to thank all those who have been helpful to the library and to state that the ordinary routine work has been very satisfactory during the year.

The only difficulty that meets us on all sides is the lack of room* in which to do our work and in which to serve the students and faculty.

Very respectfully submitted,

JOSEPH F. DANIELS,
Librarian.

*Since the writing of the report, the Board has ordered the Commercial Building made ready for the Library during the Christmas recess.

REPORT OF THE STATE BOARD OF AGRICULTURE

PART II.

REPORT OF

THE AGRICULTURAL EXPERIMENT STATION

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE SEVENTEENTH ANNUAL REPORT

OF

The Agricultural Experiment Station

For 1903-4

LETTER OF TRANSMITTAL.

To His Excellency,

JAMES H. PEABODY,
Governor of Colorado:

In accordance with the requirements of the act of Congress providing for Agricultural Experiment Stations, I have the honor to present herewith my report for the fiscal year ending June 30, 1904, it being the seventeenth annual report, together with accompanying documents which give an indication of the activities of the Station.

The publication of the experiments is in separate form, as bulletins, and widely distributed to the agricultural population of the State.

Respectfully submitted,

L. G. CARPENTER,
Director.

The Agricultural Experiment Station,
State Agricultural College,
Fort Collins, Colorado.
December, 1904.

THE AGRICULTURAL EXPERIMENT STATION.

FORT COLLINS, COLORADO.

THE STATE BOARD OF AGRICULTURE.

	Term Expires
Hon. P. F. SHARP, *President*, Denver	1905
Hon. JESSE HARRIS, Fort Collins	1905
Hon. HARLAN THOMAS, Denver	1907
Mrs. ELIZA F. ROUTT, Denver	1907
Hon. JAMES L. CHATFIELD, Gypsum	1909
Hon. B. U. DYE, Rocky Ford	1909
Hon. B. F. ROCKAFELLOW, Canon City	1911
Hon. EUGENE H. GRUBB, Carbondale	1911

Governor JAMES H. PEABODY,
President BARTON O. AYLESWORTH, } *ex-officio.*

EXECUTIVE COMMITTEE IN CHARGE.

P. F. SHARP, Chairman. B. F. ROCKAFELLOW.
JESSE HARRIS.

STATION STAFF.

L. G. CARPENTER, M. S., *Director*........Irrigation Engineer
C. P. GILLETTE, M. S........................Entomologist
W. P. HEADDEN, A. M., Ph. D....................Chemist
W. PADDOCK, M. S..........................Horticulturist
W. L. CARLYLE, B. S.........................Agriculturist
GEO. N. GLOVER, M. S.*.....................Veterinarian
R. E. TRIMBLE, B. S............Assistant Irrigation Engineer
A. H. DANIELSON, B. S..............Assistant Agriculturist
F. M. ROLFS, B. S...................Assistant Horticulturist
F. C. ALFORD, B. S.........................Assistant Chemist
EARL DOUGLASS, B. S.....................Assistant Chemist
S. ARTHUR JOHNSON, M. S...........Assistant Entomologist
P. K. BLINN, B. S....Field Agent, Arkansas Valley, Rocky Ford
J. E. PAYNE, M. S.**..........Plains Field Agent, Fort Collins

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*From June, 1904.
**Resigned April 1, 1904.

OFFICERS.

President, BARTON O. AYLESWORTH, A. M., LL.D.,
L. G. CARPENTER, M, S............................Director
A. M. HAWLEY......................................Secretary
MARGARET MURRAY..............Stenographer and Clerk

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1904.

RECEIPTS.

Dr.	U. S. Fund	Special Fund	Totals
From the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1904, as per act of Congress approved March 2, 1887	$15,000.00	....	....
From various sources	....	$ 1,313.59	....
Total receipts			$16,313.59

DISBURSEMENTS

Classification	U. S. Fund	Special Fund	Totals
Salaries	$12,277.45	$ 100.00	$12,377.45
Labor	164.45	....	164.45
Publications	709.31	....	709.31
Postage and stationery	211.61	6.15	217.76
Freight and express	6.94	....	6.94
Heat, light, water and power	6.75	....	6.75
Chemical supplies	2.50	....	2.50
Seeds, plants and sundry supplies	52.65	15.79	68.44
Fertilizers	5.00	....	5.00
Feeding stuffs	....	38.05	38.05
Library	75.28	....	75.28
Tools, implements, machinery	....	....	....
Furniture and fixtures	.70	....	.70
Scientific apparatus	455.01	180.00	635.01
Live stock	....	....	....
Traveling expenses	1,006.35	494.20	1,500.55
Contingent expenses	26.00	....	26.00
Buildings and repairs	....	....	....
Total expended	$15,000.00	$ 834.19	$15,834.19
Balance		479.40	479.40
			$16,313.59

REPORT OF THE DIRECTOR.

To the Executive Committee, State Board of Agriculture:

Gentlemen—I have the honor to present the following report as Director of the Experiment Station, and, omitting details, confine myself to the principal matters for your consideration or action.

Brief Summary of the History of the Station—The Experiment Station was organized in February, 1888, in accordance with the "Hatch Act" of Congress. Each state receives fifteen thousand dollars per year for an experiment station. The Legislature of Colorado provided that several branch stations should be established at different points in the State, specifying five in number. These were located at Cheyenne Wells, Monument, Rocky Ford, Monte Vista and Delta.

The one provided for near Delta was never organized. The Legislature made no provision for the support of these stations. For a number of years the maintenance required a large part of our revenue, and crippled the main station to a very great extent. Altogether, some sixty thousand dollars were expended in these branch stations. It was finally decided by the national government that this use was not authorized by the Hatch act, and that one Experiment station only was provided for. During the administration of the present Director we have withdrawn from the entanglements of these sub-stations to a great extent, and at present no money is required for their maintenance, and the work is of a great, if not greater, value than came during the great expenditure of money. This result has been a work of patience and care in order to allay local prejudice, and to withdraw without local opposition, which, even if ineffective, might still be serious to the Station.

During this time the rights in the land at Monte Vista, including instruments, have been disposed of, and the greater part of the money due has been paid.

At Rocky Ford, the lease of the two hundred acres of land has been relinquished to the State, the improvements of that portion of the farm sold. The remaining forty acres furnish a headquarters for the Field Agent, and gives an opportunity for some local experimentation, which has been without cost to the Station. There is still some money coming to the Station from the sale of these improvements.

The Monument Station has been disposed of by agreement, and the deed is in escrow in the bank at Colorado Springs, but

the questions concerning the title of the land have not been completely settled, and the sale has not been closed out.

The land at Cheyenne Wells was furnished by the railroad company for the purpose of a station for investigation on the plains. The station was originally termed "The Rain Belt Station," an unfortunate designation. The title of Superintendent was changed to Field Agent, and his work enlarged to cover the Eastern Plains, and the costly forming of portions relinquished. No money for the Station proper has been used, except that necessary to keep the buildings in repair. For the past two years the grounds and buildings have been leased to Mr. J. B. Robertson, who was the first Superintendent. Mr. Robertson lives on the place and raises such crops as he can, reporting the results to us. It is considered that the rent which is furnished him in the use of the house and barn is repaid by the work which he does. It seems that we obtain substantially the same results as when the cost amounted to some hundreds of dollars per year.

The Field Agent was set free for investigation on the Plains. The investigations resulted in a number of bulletins, four of which are just issued from the press. The work on the Plains, as was pointed out a year ago, was approaching an end, or change in plan, and would require more money than was available. Some negotiation for private means to take up the Plains problems on a larger scale were entered into, but these did not develop the last year. Mr. Payne was offered a more lucrative position and resigned last April. This leaves the Plains work not quite completed, but substantially so.

The problem of the Divide, and the raising of potatoes on the Divide, and general farming on the Divide, had been under consideration and preliminary reconnaissance and reports had been made for two successive years with a view of completing it this summer. Four bulletins, Nos. 87, 88, 89 and 90, on "Cattle Raising on the Plains," "Dairying on the Plains," "Wheat Raising on the Plains," and "Unirrigated Alfalfa on Upland," have been issued, and to a large extent round out this work. Until these bulletins were distributed, I have not thought the time propitious to discuss with those supporting the Station, the abandonment. The Plains Station has, perhaps, reached its limit of usefulness as a field for experimentation. As the greatest usefulness of the Station has been in the investigations, it is possible that we can withdraw from Cheyenne Wells entirely. In such case several questions arise. The title to the land seems to be in the railroad company. We own the buildings and improvements. If the land be transferred we ought to obtain something for our improvements. It is not at all likely that a sum anywhere near the cost of the buildings can be realized. We should have to reach a friendly arrangement with the company.

The results of the work of the Field Agent for the past few years have been very satisfactory, and while the former work upon the sub-station was costly and apparently without result, yet we should not forget, after all, that without this previous work much of the subsequent results could not have been obtained. In all scientific investigation a large part of the effort is what may be termed dead work, without immediate result, and does not show in the final conclusions, yet is unavoidable, and just as necessary as the final productive work.

The Office of Experiment Stations at Washington suggested that it would have been a good time to have withdrawn from this Station when Mr. Payne resigned. As there were some bulletins relating to the work on the Plains then in contemplation, and soon to be issued, I thought it would be better to let the discussion of this matter wait.

At Rocky Ford Mr. Blinn has continued as Field Agent, and a most excellent one he has been. The work has been on the problems of the Arkansas valley, and is still essentially on the lines laid out some years ago, that is, on the problems relating to sugar beets and to cantaloupes. It was desired to give more attention to co-operative work with the people of the valley. As Mr. Blinn has been doing well with the investigations which were being conducted more closely under his own supervision, I have not pushed the matter.

GENERAL NEEDS OF THE EXPERIMENT STATIONS.

When the Experiment Station was organized the revenue from the government was the same as now. For a number of years its effective revenues were taken by the sub-stations without material benefit.

During the past few years it has been the aim of the director to arrange the finances so as to obtain a working capital. The station has an equipment of men and instruments. The improvement in work is partly a question of arranging conditions to obtain the best results from this equipment. One of the important things is to have a working capital to go upon. In this we have succeeded to some extent, but careful watchfulness is necessary, both on the part of the Director and the Board. The national government is frequently reminding us that the margin between our income and our fixed charges is small, ought to be larger, and that we ought not to become responsible for more departments than can be well supported. The scale on which we have been carrying the work for a number of years requires sixteen to eighteen thousand dollars per year. The excess over the amount received from Congress has been received from several sources, partly from the sale of the improvements of sub-stations. The revenues from these sources continued for several years, but will soon come to an end.

There is considerable effective help derived from the College which does not appear in our financial statements—janitor service, heat, light, work on the farm and garden and various other expenditures are made directly from the College funds, and do not show in our statements. After one or two years, we shall receive no more revenue from the sub-station improvements. We should foresee the condition which confronts us, which is that we must lessen our expenditures, and this means a decrease in the work, or the securing of additional revenue. While our needs have been growing we have had a fixed income. Every person connected with the Experiment Station sees opportunities for valuable and important work. There are frequent requests to enter upon new lines of investigation, which are all proper, many of them desirable. The trouble is that they require more funds. Knowing the needs of the work, we have not seen how we could support new lines of investigation, and therefore have seen no other way but to report against expansion when the matter has come up.

It should be remembered that the indirect expenses are often greater than the direct. The salary of an investigator is but one of the expenses involved. In order that his time may be effective, he must have room, apparatus, help, traveling expenses, stationery and postage. In addition there is the cost of printing the bulletins which may be the result of the work. Every active investigator requires an available expense revenue of one to two thousand dollars per annum as a minimum. The larger sum is nearer the correct amount, and is about the present expense per section. I therefore do not see how we can expand the lines of work for which the Station is responsible unless a revenue of approximately two thousand dollars per section is obtainable, and then the fact that greater returns are apt to come from additions to facilities of the old sections which have been crippling along. The Department of Agriculture has admonished us of the risks involved, and that it would be better to increase the facilities for work of the sections than to start new sections.

There is great opportunity for workers in this State, the field is large, it is interesting, it is varied in its problems. I have in a previous report called attention to the fact that this State is as large as New York, and all of the six New England States; that its climate varies from that of Charleston to northern Alaska. Besides the varied problems, the agricultural population lacks the acquired experience of the East, which is a guide to what may be grown. Besides there are the problems brought in irrigation which make some forms of engineering a direct and necessary part of agriculture. There are now seven Agricultural Experiment Stations in that area supported by the general government. The States support the two independent Experiment Stations, and supplement the appropriation of $105,-

000 of the national government by State appropriations, amounting to much more.

A very important consideration for us, therefore, is the increase of revenue. The additional revenue which has helped the Experiment Station for a few years past will soon be at an end. The sources of revenue may be considered as from the Board of Agriculture, or the College, from the State Legislature and from Congress. The fundamental act establishing the Board of Agriculture recognizes investigation as within the scope of the Board of Agriculture. The Experiment Station, to a great extent, relieves the College from demand upon the College revenues for this purpose, but it is called to your attention that it is a proper line of activity of the Board, if you so consider, and that some of the revenues of the Board could be used in investigation if you think proper.

The Hatch act recognizes the Experiment Station as a part of the College, and the increasing tendency is to recognize it as the investigational side of a development of what is often termed the "University Idea," which is that of investigation, or, to use the motto of the Smithsonian Institution, it is "For the Protection and Dissemination of Knowledge."

A second possible source of revenue might be by direct legislative appropriation. This is called to your consideration, and whether effort should be made in that direction.

The third is the probable action of Congress in increasing the appropriation for Experiment Stations. It is hoped with considerable reason that the bill which has been before Congress for some time will be favorably considered this winter. If so, the effect will be to raise the income of the Experiment Station by five thousand dollars the first year, increasing that amount by annual additions of two thousand dollars until it reaches fifteen thousand dollars per year. The bill attaches some limitations.

RELATION OF THE STATION TO THE COLLEGE.

As above stated, the Station is defined in the Hatch act as "A Department of the College." The act does not specify what is meant by "Department." In this institution "Department" is used in a special sense, which may be, but probably is not, the same as intended in the act; at any rate, the act implies a close union between the Station and the College, and, as before suggested, its duties are primarily for investigation and the dissemination of the results of its investigations. The College has recognized at all times the close union between the purpose of the Experiment Station and the purpose of the College, and that the Experiment Station is one of the most valuable features of the College in securing a broader purpose of the institution.

There is undoubtedly an increasing tendency to recognize the work of experimentation as one of the most important which the institution can do, and to arrange conditions so as to favor experimentation. There has always been a desire in this institution to help in the same way. The College has given a good deal for experimental purposes by indirect expenditures, and at times has appropriated money to the various departments for this purpose. A logical recognition of the Experiment Station as the investigational branch of the institution has not followed. We have not obtained the credit with other states and with the government authorities which such activity would justify, from the fact that the financial records of the Experiment Station do not show the amount that has thus been expended. The appropriations of the Board in such way are proper and to be commended. It is likely that greater need will be felt in the future, and that the Board will not only continue to appropriate for this purpose, but increase the amount. The conviction in my mind has been emphasized by the discussions relating to the bills now before Congress, that it might be well to recognize the Experiment Station organization as the investigational part of the institution in such a way that all investigational work relating to agriculture should be associated with the Experiment Station under the same general regulation and requirements as the work paid for directly from the Hatch fund, and that it would be an advantage in our financial records if these appropriations were made, or shown, as an appropriation to the Experiment Station Department, just as other appropriations are made and charged to the mechanical or other departments. This also would relieve the Director, and I presume the President of the College, of certain other embarrassments, and might prevent difficulties which the situation will be apt to cause in the future, though they have not yet arisen. I refer to questions of divided authority and divided responsibility. As it is, there are several in the College whose work is principally experimental. They are not paid from the Hatch fund because of lack of funds. One is on the staff of the Experiment Station, though not paid from that fund. Several others are not on the staff, but their questions relating to experimentation are brought to the Director for consultation. The Director is under embarrassment, in such matters, and uncertain as to where his authority extends or where it is expected to extend.

The Station does not have their names on its staff, though to all intents and purposes they should be so considered, and the Station and these individuals lose the credit attached thereto. It is probable that in such cases the question of experiments would not be taken up by the President of the College, and therefore there arises a condition where the worker may not feel responsible to the Station or to the College, and where both the President and the Director feel some delicacy in making

suggestions or directions, and might easily lead to a situation where the worker could have means for experimentation without the responsibility. Fortunately such conditions have not resulted, but it is well to consider the condition.

The suggestion which I would therefore present for your consideration would be that the appropriations for experimental purposes be considered as an appropriation to the Experiment Station, and should show in its financial record as "other sources of revenue;" that the amount required for these investigations should be placed to the credit of the Station, or arranged in such a way that it would be expended in the same way as other Experiment Station funds, and should show in the account. That in the case of men like Mr. Olin, Mr. Griffith or Dr. Glover, that a certain portion of their salary be considered as paid from Experiment Station funds, and should show in the financial account of the Station. Their names could then be added to the Station staff, to the mutual credit of the worker and the Station, and their work could be carried on under definite approved plans as in the case of other members of the Station staff, and the cost to the College will be no greater than it has been, and probably less. It is certain that the institution has not received credit for its activities in this line, and it is probable that the members of the Board themselves have not realized the amount. Some such method would simplify the problem of the Station and probably that of the College, would recognize the investigational work as a proper function of the College, and would tend to organize it in such a way that would be beneficial and effective.

PUBLICATIONS.

The publications of the Station during the year just past include Bulletins from 84 to 92, inclusive, and there are now two in press—one by Prof. Gillette, and an important one by Dr. Headden on digestion experiments, which reports the work being carried on for a number of years. A number of other bulletins are nearly ready for publication. The standard edition is about 9,000. We hope that the present report may be published without expense to us.

BILLS BEFORE CONGRESS.

There are now two bills before Congress which affect the activities of the Station. The first is the Adams bill, increasing the Hatch fund. This provides that the Stations shall each receive an increase of $5,000 per annum, and an annual increase of $2,000 per annum thereafter, until the total of $15,000, which would be at the end of five years. This will enable the Stations to gradually increase their work by natural growth instead of by a sudden expansion, which is apt to be wasteful. It is greatly hoped that this bill may be passed. Considerable work needs to be done before Congress and by the Stations. There is a

limitation in the bill which prohibits this fund being used for salaries.

The other bill is the bill introduced as the Mining School bill, and which largely by your support has been amended so that it is also available for agricultural and irrigation engineering and forestry. The bill is introduced now in this latter form, and has passed the committee, and is on the calendar. Half of this fund would be available for our institution. This is a case where one-half is probably better than the whole, because the half which we receive materially aids the fundamental purposes of the institution, while were the whole amount to be received it would involve a change of work and increase of obligation, which would require all of the fund for mining work. The bill provides for a separate organization analogous to the Experiment Station, with considerable elasticity in its relations to publication and investigation. The superintendence of this work would not be under the Department of Agriculture. The additions to the bill are drawn so that any state other than mining states would find useful application for the money. It was not expected that all of the topics mentioned in the bill would be taken up by any one state. This bill provides for an appropriation starting at $10,000, and thence increasing by $1,000 per annum until it reaches $20,000. Under this our appropriation will start with $5,000, increasing thereafter $500 per annum until it reaches $10,000. This bill is pushed by a different house committee from the one favoring Experiment Stations. There is some reason to hope that this may also pass, but, of course, there are many uncertainties involved and which can not be determined until actually passed. This bill would be an aid to the Experiment Station, because it would be an additional endowment for lines of work which have been recognized as being fundamental for agriculture in this State.

THE KANSAS-COLORADO CASE.

It is proper to call special attention to this case, because it is such a radical attack upon agriculture of the State. It is not, as has often been supposed, a contest for priority of use on the same stream. On the other hand, the complaint by the state of Kansas involves the denial of the right to irrigate by the people in the Arkansas valley, and if the principle were recognized there, it would involve the right to irrigate on the Platte, the Rio Grande and the Grand river, and would affect almost every stream in the State. It has properly been viewed by the Board as a fundamental question in our agriculture. The previous work of the Experiment Station has been instrumental in outlining and shaping the lines upon which Colorado has rested its case. This case is the first one in which there has been a square conflict between the eastern doctrine of riparian rights

and the doctrine of appropriation, which all peoples have recognized in arid countries.

Since the last regular meeting of the Board the Kansas-Colorado case has been in process of hearing. A commissioner was appointed by the United States Supreme Court. Sessions were held at the various towns in Kansas and Colorado for the presentation of evidence by Kansas. The defense by Colorado was begun in Denver in October, and is now continuing at various towns in the Arkansas valley. It will be several months before the testimony is concluded. As a summation of the situation so far, it may be said that Kansas attempted to show that the Arkansas had decreased or dried up since the construction of ditches in Colorado; that this decrease has affected navigation, and the crops in the bottom lands; that it has affected the underflow, and that Kansas has a claim for damages for past injuries, but also a right for the ordinary flow of the stream in the future.

The Colorado defense essentially denies this view of the law, but, granting that it is true, it denies that the river is drier than it used to be; that the construction or taking out of ditches or the diversion of water in Colorado has had any effect on the water of the Arkansas; that the evidence of a change of river presented by Kansas is a mistake, or, at any rate, that the river has been habitually dry from Lamar to Great Bend, and that ditches in Colorado have had no appreciable effect upon the river in eastern Kansas.

The government apparently takes the view—

1. That the doctrine of appropriation is a proper doctrine for this country, in that respect agreeing with Colorado; but that the doctrine should be recognized irrespective of state lines. There is some indication that the government may desire to take control of the interstate streams and distribute water therefrom, a situation which might be almost as harmful as the original contention of Kansas.

FLORA OF COLORADO.

The bulletin on the Flora of Colorado, which was to include the work done by the Experiment Station for a number of years, and to complete that investigation, seems to be now ready for publication. The work of the preparation of the manuscript has been done by Dr. Rydberg, of Columbia College, and the New York Botanical Gardens at Bronx Park, New York City, who is recognized as the highest authority on Rocky Mountain Flora. The arrangement practically was that we should pay for the clerical work; that we should have the advantage of his knowledge, and he the use of this collection. The work of preparation has extended over several years. The manuscript was expected to be available a year and a half ago. The special appropriation made by the Board of $1,000 has been held available in order to cover the anticipated cost of this publication. A re-

cent letter from Dr. Rydberg says that the manuscript is now practically ready, and arrangements need to be made for its publication.

The publication of this bulletin of 400 pages involves several questions. It will be a standard work and in great demand. The cost of publication will be considerable, and a free distribution to all who want it would manifestly be beyond the means of the Experiment Station. The Station could not afford to print as many copies as would be required. The Station can not accept any money for its publications. It has therefore been a subject of serious consideration as to how to treat this proposition. A discussion with the Office of Experiment Stations has resulted in this conclusion—that a limited edition can be printed by the Experiment Station sufficient to distribute and fulfill the requirements of the law. This would be an edition not to exceed 2,000 copies; that, then, an additional edition with a change of title page could be issued in the name of the College, and these bulletins sold at some price dependent upon the cost of publication. In this way the needs of those who want the Flora, and are willing to pay for it, could be met, and the cost would be relatively moderate, and the extra edition could be made to at least partially pay for itself.

The alternative is an appropriation sufficient for this purpose, and the matter is referred to you for consideration.

The 2,000 copies of the bulletin will cost in the neighborhood of $1,600 or $1,800. The price for which the copies could be sold by the College would be $1 or $1.50.

BUILDINGS.

A pressing need of the Station as a whole is a biulding wherein its work can be carried on. The building planned for the Irrigation Engineering Department was adapted for this purpose, and had what is very much needed—two ample fireproof vaults. The records of the Station are of very great value, and those which depend upon time could never be replaced. The loss of such data as we have obtained would represent the loss of some sixteen years of effort, and could not be replaced at any cost. It is therefore a matter of great importance to the Station that some suitable means be available for some storage and preservation of such records, and at the same time that they may be available, and if no loss takes place no damage will have resulted. If, however, fire does occur, it would be absolutely impossible to replace them. Some of this data is unpublished, inasmuch as the investigations bear upon matters which have been in dispute between Colorado and some of the adjacent states.

I attach herewith reports from the different sections of the Experiment Station, giving the reports for the current year, all

of which are commended to your attention. From the Station staff I asked for a summary rather than a detailed report—a summary of such character as to give an understanding of the scope of the work and of the character of the results obtained.

Respectfully submitted,

L. G. CARPENTER,
Director.

REPORT OF THE ENTOMOLOGIST.

To the Director:

I have the honor to present herewith a brief summary of the work af the Entomological Section of the Agricultural Experiment Station for the year 1904. I am also appending an invoice of the Experiment Station property held by this section, a proposed outline of work to be undertaken during the year 1905, and an estimate of the amount of money that will be required to properly carry on the work.

INSECTS OF THE YEAR.

The Codling Moth (Carpocapsa pomonella)—The more active work of the section to determine the habits and remedies for this orchard have come to a close with the work of the past year. The main points in the life habits of the insect in Colorado are now well established. Those who have followed closely the advice of this Station in the treatment of their apple orchards the past year have not averaged more than five per cent. of wormy fruit, as indicated by actual counts in many orchards. Orchards adjacent to those treated, but which were neglected, have suffered a loss of from 50 per cent. to 95 per cent. of their fruit from the attacks of the worms. Arsenate of lead was used in many orchards in the State the past summer, and has met with almost universal praise. Our experiments and observations are all to the effect that the first treatment, if made thoroughly when the petals have just fallen, is of more value than all the spraying that can be done after the calyces have closed, and that more than two or three sprayings are seldom advisable. A bulletin on this insect is in preparation.

The Beet Web-worm (Loxostege stiticalis)—This insect did quite extensive injuries to sugar beets in Colorado the past summer and fall. It did noticeable injuries in all the beet-growing sections, except those above Loveland and Longmont. We have gathered valuable data upon the life history of this insect, and also upon remedies that may be used for its destruction. We are planning a bulletin to be sent to the beet-growers early in the spring.

Cutworms.—Cutworms belonging to the genus *Chorizagrotis* were very destructive to young beets and other cultivated crops in 1903 in northern Colorado, but gave no special trouble the past year. On August 19th, of this year, Mr. P. K. Blinn took the writer into an alfalfa field at Rocky Ford where the larvae (cutworms) of *Peridroma saucia* were very numerous under

cocks of alfalfa hay. The species seems to be partial to alfalfa in this State. From the worms taken at Rocky Ford moths appeared in our breeding cages September 13th and later.

Mountain Crickets (Anabrus simplex)—This large, black, wingless grasshopper, commonly called "Mormon Cricket," "Idaho Cricket," and "Mountain Cricket," has been on the increase for some years past in Routt county, and the past summer was a serious and formidable pest in portions of that country where cultivated crops are grown. Mr. S. A. Johnson, first assistant in this section, accompanied a camping expedition from the Experiment Station through the infested districts and accumulated much valuable information in regard to the habits of the insect this year and the history of its marching armies in past years. The writer spent several days in a badly infested section and made a study of the life habits and remedies that might be used to prevent future depredations. The outlook at present is very bad for those ranchmen who live in the immediate vicinity of any of the breeding grounds of the cricket, as eggs were deposited in perfectly enormous numbers last fall, and to the present writing are wintering well, samples of eggs having just been received from two parties, Mr. W. W. Miles, of Eddy, and Mr. J. H. Yoast, of Dunkley, and in both instances the eggs were nearly all healthy in appearance and contained little crickets ready to hatch when warm weather of spring should come.

We have a bulletin upon this insect planned for publication during the latter part of the present winter.

Grasshoppers—The common destructive grasshopers, or locusts, have been less numerous than common the past year, very little complaint having been received at this office.

The Potato Flea-beetle (Epitrix cucumeris)—This little black flea-beetle was especially abundant in the potato fields of the Greeley district in the past summer, where they caused many thousands of dollars of loss to growers. The injuries were not so much to the tops as to the tubers themselves. The larvae (worms) were very numerous, eating holes into the potatoes during September, causing the latter to become scabby and unsalable on a slow market. Mr. S. A. Johnson prepared press bulletin 23 upon this insect, which was issued during September. He is also preparing a fuller account of the habits and remedies of this insect, along with one or two other potato pests, with a view of publishing the paper as a regular bulletin during the coming year.

The Woolly Apple-louse (Schizoneura lanigera)—Considerable work has been done upon this insect during the past year, and we hope to continue our work with it the coming season, as it has become one of the most dreaded apple tree pests in the State. Among other things, we are testing supposed resistant varieties of apple trees.

The Green Apple-louse. (Aphis pomi)—This insect is also a serious pest in many of the apple orchards on both sides of the range. Many orchardists are considering it a worse pest than the codling moth, because they have learned to control the latter insect with comparatively little trouble and expense. This louse seems to be equally bad upon pear trees. We have found nothing better than kerosene emulsion for its destruction, but tree-soaps and tobacco decoctions may also be effectually used against it.

Lice Affecting Pine and Spruce (Chermes sp.)—Yellow pine *(Pinus ponderosa)*, Pinyon, or Nut-pine *(Pinus edulis)*, and our common spruces *(Picea pungens*, and *Pseudotsuga douglasii)* all have species of lice belonging to the genus *Chermes* that attack the leaves and new growths, doing considerable injury to the trees and making them unsightly, particularly when planted in lawns. The presence of these lice is recognized by the galls, or the distorted leaves that they cause, or the white waxy secretions that hide the lice and their eggs. The habits of these lice have been studied and a paper treating of them is about ready for publication, and will be fully illustrated.

The Black Peach-aphis. (Aphis persice-niger)—This insect is becoming more and more troublesome each year in the peach-growing sections. I believe it is important that the Station should take up a study of the habits of this insect, along with the testing of remedies for its destruction on both the tops and roots of trees. Most complaints of injuries have come from Canon City and Delta.

The Cottony Maple Scale (Pulvinaria innuemrabilis)—Mr. S. A. Johnson has had in charge experiments for the destruction of the cottony maple scale in one of the parks in Denver, where he has worked in conjunction with the park authorities. This scale has become a serious pest upon both soft maple and locust trees from Boulder south to Pueblo. The experiments have resulted quite successfully and will be reported upon by Mr. Johnson. This section is much indebted to Mr. Schultze, superintendent of parks, and to one of his foremen, Mr. W. B. Smith, for permission and assistance in carrying on the work.

The Rose Scale. (Aulacaspis rosae)—The first examples I have seen of this insect in Colorado were sent me by Mr. Scott, upon blackberry canes, from Boulder. The canes sent were badly infected.

Respectfully submitted,

C. P. GILLETTE,
Entomologist.

Fort Collins, Colorado, December 10, 1904.

REPORT OF THE CHEMIST.

To the Director:

The work of the Chemical section since my last biennial report has touched some very important questions of our Western agriculture, and a few of interest to the State in a still more general way. The most important work completed during this period is the study of the ground waters, drain waters and return waters already published in two bulletins, Nos. 72 and 82. These will soon be followed by one on some digestive experiments made with our Colorado boys. This bulletin, however, will not complete the amount of work done on this subject, as we are extending it to include a study of their digestibility, taking the portions soluable in different menstrua, i. e., cold water, alcohol, etc., as our units. We are extending the work to an attempt to determine the digestibility of the pentosans. This work will be completed in the near future, and a bulletin containing the results obtained will be presented in the latter part of the spring or early summer of 1905.

In this connection it seems advisable to determine the calorific values of the different fodders and dungs. I have already asked for quotations on a calorimeter, and find that with clay capsules, etc., it will cost about $130.00, but, with combustive capsules of platinum, about $210.00. I believe that the determination of the calorific values of fodders will be more frequently made in all digestion experiments in the future than has been the case up to the present time. I would, therefore, request permission to purchase one.

Several years ago we collected and analyzed a number of artesian waters from the San Luis valley. This work has not been published, and for some reasons I do not regret it, because it seems to me to be of sufficient interest to justify us in taking it up again to study more fully the composition of these different waters. The work already done has served a good purpose already, though unpublished. The United States Geological Survey has done some work on these waters, but, to the best of my knowledge, there is neither conflict with our work nor even a repetition of it. I would respectfully suggest that it is perfectly legitimate and proper for us to obtain large samples of waters from typical wells, for it is out of the question for us to analyze all of the wells and submit them to a much more thorough examination than was possible with the small samples formerly taken.

The brown water from Mosca, for instance, proved to be very interesting, indeed. We have already done more work on

this water than on the other well waters, and almost as much as on the San Luis Lake waters, whose composition also presents some interesting questions.

While the time and labor necessary to give a reasonable degree of completeness to this work is quite considerable, I believe that it is of sufficient interest to justify us in doing so. We attempted, at the time we took samples of the well waters, to obtain samples of the Rio Grande del Norte water at different points in the course of the river to study the changes in its composition, as we have subsequently done for the Cache a la Poudre. So long as we have already obtained partial results of this river, I think that it would be proper for us to extend and complete them, at least to such an extent as to make them available as an independent study of the Rio Grande waters. The amount of work which this would require would depend upon how far down the river we took samples. My idea relative to the work on this subject is that we might extend it sufficiently to make what we have already done of some more value and complete so far as it should go, but I would scarce follow the stream further down than the mouth of the Rio Hondo, and in this case it would not be advisable or practicable to take more than one or two samples, at the most, between the State bridge and this point.

During the past years we have made a few analyses of mineral waters, some of which are of sufficient interest—perhaps I should say merit—to justify their publication. These waters are of interest to the State at large, though they may at the present time be the property of individuals. Any interest that these analyses may possess would, of course, appertain to the State of Colorado, or be of a purely scientific nature. I shall be pleased to prepare this material for publication in some future report.

The lines of work now being pursued by the Station are:

First—On the digestion experiments of some of our Colorado hays, as already stated.

Second—On the deterioration of farmyard manures under our Colorado conditions. We believe this to be an important question for this State, as the time is already here when it behooves the farmer to husband every means by which he may maintain or increase the fertility of his land.

Bulletins which can reasonably be expected from this department are one on digestion experiments, by early summer; one on methods of extracting beeswax by early fall; one on alkalies, provided we can obtain certain material which has been promised us. Samples from various parts of the State have already been analyzed and considerable material has been accumulated for this bulletin, which will be a brief one. I am very anxious to obtain the collection of material which has been

promised me. If it can be obtained it will add very much to the interest and value of the bulletin.

I have no other requests to make or recommendations to offer at this time.

Respectfully submitted,

W. P. HEADDEN,
Chemist.

Fort Collins, Colorado, December 8, 1904.

REPORT OF THE HORTICULTURIST AND BOTANIST.

To the Director:

I have no other requests to make or recommendations to offer of Horticulture and Botany for the past year:

Our work with potato diseases has progressed satisfactorily, and we are now able to state positively that the usual failures of the potato crop, such as the production of vines with no tubers, or a cluster of little potatoes, and in many instances a poor stand of plants, are caused by the attacks of a certain plant disease. But no successful method of combating the disease has yet been devised. Our soil in Colorado seems to be so thoroughly impregnated with the fungus that the usual methods of seed treatment are usually of no avail. We are now bending our energies toward the production of a strain of potatoes that will resist the attacks of the fungus. With this end in view we have tested numerous varieties of potatoes by growing them on diseased soil; a number of seedlings have been produced which are also being tested; and the next year about fifty varieties of potatoes will be tested in co-operation with the Department of Agriculture. These varieties were obtained in Europe, and were selected because of their vigor and freedom from disease.

Most of the work of investigating the nature of this fungus has been done by Mr. Rolfs, and he has been able to establish several facts which were new to science. Notable among these is the fruiting stage of the fungus. For a long time this fungus has been regarded as sterile, or non-spore bearing. We find that it produces spores abundantly, and culture experiments have shown the connection that exists between the two stages in the life history of the plant. Bulletins Nos. 70, 91 and 92 treat of this subject.

In connection with our work with potatoes some experiments were conducted in seed treatment and seed selection, as well as with commercial fertilizers. These experiments were all on a commercial scale, and were carried on in co-operation with the Bliss Brothers, of Greeley.

The results of these experiments are given below without comment. The ground had been in potatoes the previous season thus making this the second successive crop. In all cases five rows are equivalent to one acre of ground. The results include only the salable sorted potatoes.

Table I. Results of treating seed with corrosive sublimate solution and of seed selection.

No. of rows	Treatment	No. of sacks	No. of pounds
6	Treated with corrosive sublimate	73½	8,820
6	Some evidence of Rhizoctonia on all seed	69½	8,340
2	Choice selected seed	24	2,880
2	Cull seed	22	2,640
6	Check	63½	7,620

The Banner variety was used in the above experiments.

Table II. Results of the application of commercial fertilizers.

No. of rows	Material applied	Yield No. of sacks	Yield No. of pounds
5	Nitrate of soda, 100 lbs	39	4,475
5	Bone meal, 150 pounds	60	6,960
5	Sulphate of potash, 75 lbs	40	5,680
5	Nitrate of soda, 100 lbs.; bone meal, 150 lbs.; sulphate of potash, 75 lbs	42	4,870
5	Nitrate of soda, 100 lbs.; bone meal, 150 lbs	42	4,870
5	Nitrate of soda, 100 lbs.; sulphate of potash, 75 lbs	37	4,240
5	Bone meal, 150 lbs.; sulphate of potash, 75 lbs	59	6,870
5	Bone meal, 75 lbs.; sulphate of potash, 50 lbs	57	6,650
5	Check	50	5,830

Pearl seed, grown in the mountains, was used in the above experiments.

SHADE TREES.

Much time has been given to studying the shade trees of Denver with the idea of publishing our observations, together with photographs, in bulletin form. More attention has been given to tree planting in Denver than in any other locality in the State. As a result there are at least sixty-six kinds of trees growing within the environs of Denver that are foreign to the State. The result of the experience with some of the more promising kinds will be of great value to prospective tree planters.

CORN BREEDING.

At the request of Mr. F. L. Pickett, of Edgewater, we entered into a co-operative experiment with him in breeding a type of field corn that will be suited to our conditions. Mr. Pickett has been growing a variety of corn for a number of years that usually

ripens and yields fairly well. But it lacks a well-defined type, and needs improvement in many respects. A number of the best seed ears were selected and plats were planted on the College grounds and on Mr. Pickett's farm.

The seed from individual ears was planted in separate rows, as a basis for selection. A great amount of variation was seen in the different rows when the corn came to maturity. Some of the rows did not produce a single ear of merit, while on others a number were selected for future planting.

The results of this preliminary test are so promising that it seems highly probable that a corn can be developed in a few years that will ripen in this locality, and that will yield paying crops.

This experiment has now been turned over to the Professor of Agronomy, who proposes to carry it through to completion.

A NEW APPLE DISEASE.

An apple disease, which is probably new to science, has been observed in various parts of the State. The fungus causing the disease (a species of *Alternaria)* has been studied, and inoculation experiments have proven that it is the cause of this apple decay. While this disease has not been at all serious, it is nevertheless desirable that the nature of the fungus be understood. If at any time it should become destructive, Bordeaux mixture will undoubtedly prove an efficient remedy.

PEAR BLIGHT.

Some studies have been made of the relation of soil moisture to the prevalence of pear blight. It was proven by exeperiment, a number of years ago, that if one could control the water supply he could check the ravages of pear blight. No orchards have yet been found where experiments of this kind could be tried on a commercial scale, but studies were made in an abandoned pear orchard, and the conditions which exist there prove that pear trees can thrive on much less water than is ordinarily supposed, and indicate that much may be done in checking blight by withholding water.

We hope to publish the result of these observations in bulletin form.

It is the expectation of horticulturists, however, that blight-proof varieties of apples and pears will eventually be produced. With this end in view, we have secured a quantity of apple seed from Mr. J. S. McClelland. The seed is from the Utter Red, a fall variety that has never been known to blight in this locality. This will be planted next spring, and the resulting seedlings will be grown to bearing age in the hopes that at least one among them may prove to be a winter apple of merit and blight resistant.

HORTICULTURAL CONDITIONS OF THE STATE.

A number of trips were taken during the season through the fruit districts of the State for the purpose of keeping in touch with the fruit growers and studying the varying conditions that exist. Much valuable information and data is secured in this way which is of inestimable value to the department, and which we also hope results in some good to the fruit growers.

Respectfully submitted,

W. PADDOCK,
Horticulturist and Botanist.

REPORT OF THE AGRICULTURIST.

To the Director:

Sir—I have the honor to submit herewith a brief summary of the experiment work undertaken in this department during the past year.

As you are aware, the funds available for the carrying on of experiment work in this department are very small, consequently, the work has not been as thorough nor as extensive as it might otherwise have been. On the whole, however, we have accomplished something that will be of substantial benefit to our farmers in the way of investigations along animal husbandry and agronomy lines. In an accompanying report, prepared by Mr. Danielson, my assistant in experiment work in agronomy, is given a summary of the work done along this line. The work of agronomy, we expect, will be materially broadened and extended during the coming year, particularly in co-operative work with farmers throughout the State. Professor Olin will have charge of this work in the future, and will have Mr. Danielson as his aid and assistant. Mr. Olin has very extensive plans for the immediate future, and a full report regarding it has been submitted to the Board of Agriculture with the Agricultural College report, a copy of which accompanies this. We feel very much the lack of funds for carrying on the investigation work in agriculture, which is probably the most extensive line of investigation. We trust that a special appropriation for the carrying on of the proposed co-operative experiments undertaken by Mr. Olin may be forthcoming from the Legislature the coming winter.

The following brief summary of the experiment work in animal husbandry, which has been carried on with the assistance of Professor C. J. Griffith, is presented at this time:

Experiments in Fattening Steers Upon Beet Pulp. During the early part of last winter a somewhat extensive feeding experiment was undertaken in conjunction with the Great Western Sugar Company and the Department of Agriculture, at Washington. Owing to the lack of funds for carrying on this work by the Experiment Station, the Great Western Sugar Company very generously provided the steers and all the equipment, including the feed and labor for carrying out of the experiment. The Department of Agriculture, through Secretary James Wilson, agreed to pay the salary of the expert to take charge of and direct the experiment and to compile the resulting data. The results of this experiment are already very well known throughout the State through the medium of a brief press bulletin. The full report of

the work is now ready for the printer, and will be published in bulletin form in the near future. I may briefly say that 150 steers were fed on the experiment, weighing approximately 900 pounds each. These were divided into three lots of fifty each. Lot No. 1 was fed beet pulp, alfalfa hay and a mixture of ground oats and ground barley, while Lot No. 2 received beet pulp, alfalfa hay and ground corn. Lot No. 3 had a ration of beet pulp and alfalfa hay, without grain feed of any kind. All of the steers in each lot had all of the pulp that they would consume at all times, without waste. The steers in Lot No. 2, fed upon a ration of beet pulp and ground corn, made the greatest gain during the experiment, and the steers fed on beet pulp and alfalfa hay made the least gain, while the lot fed on a ration of beet pulp, alfalfa hay, barley and oats, was intermediate between the others as to the amount of gain. An accurate account was kept of the different kinds of feed eaten by the steers in the different lots, and record was made of the weekly weights and gains of each lot of steers. It is interesting to note that at the close of the experiment, when everything had been charged to the steers and the total gains credited at market prices, that the lot fed pulp and alfalfa hay only, returned a profit of $16.60 for each steer; the lot fed upon a ration of pulp, hay and corn returned a profit of $15.45; while the lot fed a ration of pulp, barley, hay and oats made a profit of $12.55 each. The final results were not such as anyone who visited the steers during the experiment expected, since the lot fed upon corn in conjunction with other feed was considered to have a big lead upon the other two lots. The reason for the poor showing of the lot fed barley and oats, in comparison with the lots receiving the other feeds, may be attributed somewhat to the prevailing high price for these two varieties of grain. The steers were marketed in Denver, and were subjected to a slaughter test in the Western Packing plant, the results of which were even more surprising than the results of the feeding test. The expert buyers in the stock yards very kindly consented to grade the steers according to their market value on foot, and, while the steers fed pulp and hay were considered less valuable, per hundred weight, than the steers in the other lots, and when dressed out, a smaller percentage of dead meat to live weight, yet, when the meat of a representative steer from this lot was compared with a representative steer from each of the lots fed upon grain, it was found that it was equal, if not superior, in juiciness and flavor, and had superior edible qualities generally. The practical value of this experiment has been clearly demonstrated in northern Colorado in the past few months in the unprecedented demand there has been for beet pulp for feeding purposes. Before the beets were harvested the entire supply of pulp from the various sugar factories had been contracted for in advance and the many feeders who wished to feed cattle and sheep upon beet pulp from the factories had to be turned away because of the fact that there was not enough pulp available to supply them, while last year

there was very little demand for pulp for feeding purposes, and hundreds of tons were left at the silos at the factories that could not be disposed of. An experiment somewhat more extensive has been planned in conjunction with the Great Western Sugar Company to be carried on the coming year at the Fort Collins factory. This, it is hoped, will give us a more definite idea of the comparative value of beet pulp for fattening purposes.

Feeding Experiments With Western Lambs. A small experiment has been undertaken in fattening western lambs for market. Owing to the many inquiries that were received from farmers in several of the higher valleys in Colorado as to the feeding value of field peas for fattening lambs, a small experiment was started along this line at the College early last spring. A small area, such as could be spared from the College farm, was set aside for the growing of field peas. These were sown somewhat late in the season, and when the crop was ready for harvesting, 100 head of lambs were purchased from a ranchman in Wyoming, consisting of fifty Merinos and fifty Black Faces, and turned upon the peas as they were grown upon the land. During the seven weeks that the lambs were fed on the pea field the 100 lambs gained approximately 1,700 pounds in weight, or an average of seventeen pounds each. The lambs did very well, and cleaned the field of peas perfectly, with practically no waste. The feeding of the lambs has been continued in yards at the College barn, using corn with alfalfa hay for one of the lots, and speltz with hay for the other. We expect to market these lambs in a couple of weeks, as they are in very good condition at the present time.

The Production of Pork in Colorado. In the last annual report of the Denver Stock Yards it was shown that of the 130,000 hogs marketed, over 100,000 came from Kansas and Nebraska. This would seem to be a very serious condition of affairs concerning the pork production on the farms of our Colorado people. In order to get some light on the subject that would be of value to those of our people who might engage in this industry, ten sows, heavy with pig, were purchased on the Denver market, early in the spring of the past year. One hundred and ten dollars was paid for these sows, and we were fortunate in securing some seventy-six pigs from the lot. These pigs were fed in different lots, of twenty-four each. One of the lots had a pasture of alfalfa hay, another of rape, and a third of barley and peas. An accurate account was kept of all the grain fed to the sows from the time of their arrival on the farm until they farrowed, and from weaning until they were marketed. The total amount of feed fed to each lot of pigs and of their dams, while sucking them, was also carefully tabulated, and a brief summary of the results is given, as follows:

The sows ate of feed, before farrowing, 972 pounds of a mixture of equal parts of ground wheat, ground barley and shorts, that was worth approximately $1.00 per hundred weight. From

the time the sows were weaned of their pigs until they were marketed, they consumed 3,738 pounds of a mixture of equal parts of ground corn, ground barley and shorts, worth approximately $1.00 per hundred weight. The total cost of the feed for the sows from the time of arriving at the farm until sold, except during the period while they were nursing, was $47.10. The sows when put on the market, realized 5 cents per pound, the weight being 3,167 pounds, amounting to $188.55. After deducting the first cost and the cost of feed while nursing pigs, which amount was charged as feed of pigs, the sows returned a profit of $31.25. As before stated, the ten sows farrowed seventy-six pigs. Four of these were lost before weaning time, from one cause or another. Seventy-two of the pigs were fed on an experiment, in three lots of twenty-four each. One of the lots pastured on alfalfa with grain additional; one on rape pasture with grain, and the other on a barley and field pea pasture, also with grain feed additional. The three lots of pigs were fed a mixture of ground grains composed of one part wheat, one part barley and two parts of shorts, until two months before marketing, when the grain feed was changed to a mixture of one part corn, one part barley and two parts shorts. During the last three weeks before marketing the feed consisted of one part corn and one part shorts. The total amount of grain feed eaten by the pigs from birth until marketed, including the amount eaten by the sows while nursing, was 44,936 pounds. The pigs, when sold, weighed 13,103, requiring, therefore, approximately 3.5 pounds of feed for one pound of grain. The price received was $5.25 per hundred weight, the total amount received from the sale being $697.91, leaving a profit over cost of feed for the pigs of $248.55. The profit of the sows over the cost of the feed was $31.25, making the total net profit of both sows and pigs, over the cost of their feed, amount to $279.80. This experiment has demonstrated that there is a good profit to be made in the rearing of young pigs, since the prices charged for the grain feed was above the market quotations, and the brood sows can usually be reared on the farm at less cost than we had to pay for them immediately before farrowing.

We expect to prepare a full report of this experiment for publication in the near future, and hope to duplicate the work on a more extensive scale the coming season, as it is apparent that the farmers of Colorado are neglecting one of the most valuable features of their animal husbandry in not raising more hogs upon their farms.

Horse-Breeding Experiment. Owing to the conditions under which we are attempting to carry on the experiment work in the Agricultural Department, I see more and more clearly the importance of following your suggestion in confining our work to two or three main lines and making those strong, rather than attempting to cover too much ground, and not being able to do the work thoroughly and get results that are conclusive. Owing to the introduction of the extensive co-operative experiment between

the Department of Agriculture, through the Bureau of Animal Industry, with this College, in the breeding of horses, I am of the opinion that it would be wise to confine our work to two or three main lines of investigation, which, together with the necessary expense and labor entailed in the experiment breeding work, which should probably have first place in our endeavors during the next few years at least. We will hope to continue our investigations as to the feeding value of beet pulp for cattle during the coming year. In fact, arrangements have been made with the sugar factory in Fort Collins, to have an extensive experiment along this line carried on the present winter. We should, also, I think, continue with our investigations in the feeding and rearing and fattening of pigs. Outside of these main lines of endeavor we may be able to carry on some minor work along animal husbandry lines, but will not attempt anything very extensive, or that will require much expenditure until more funds are available for these lines of work.

Respectfully submitted,

W. L. CARLYLE,
Agriculturist.

REPORT OF THE VETERINARIAN.

To the Director:

My association with the Experiment Station dates from June, 1904. On the 15th of the same month I received the appointment as Expert Investigator of Scabies in Cattle, from the Secretary of Agriculture, temporarily, for the summer months. Primarily, this was for the purpose of making a careful investigation into range conditions with special reference to cattle mange on the plains of the eastern section of the State, and poison weed losses in the vicinity of Roaring Fork and Gunnison rivers.

As this appointment came through the Secretary of Agriculture, and separate and distinct from the Experiment Station, the report of this work will be made in due time, directly to the Department of Agriculture at Washington.

There is a great work for the Veterinarian in this State. While our flocks and herds are as free from disease as can be found anywhere on earth, yet the annual mortality in the aggregate is quite large, and much greater than it should be. The following diseases, named in the order of their importance, are responsible, in a great measure, for this loss: Mange (cattle and sheep), poisonous plants (loco, larkspur, camas, etc.), symptomatic charbon (black leg), fungoid diseases (actinomycosis and actinobacillosis), contagious abortion, epizootic keretatis. During the coming year I have planned to specialize on the first two subjects named.

SCABIES IN CATTLE.

I have, on the College farm, some cattle affected with mange, which were furnished me by some parties in Yuma county, to be used for this work.

The other things we especially wished to determine in this connection are as follows: 1. The life history of the parasite. 2. Can the eggs survive the dip, and thus infect other animals following through the vat? 3. To experiment with various crude oils, and determine if there be a dip that will suffice with one application. At the present time it looks as though the extensive dipping of range cattle during the past two years, combined with the unusually favorable conditions last season, had gotten the disease well under control in many of the worst infected sections of the State. I am satisfied that much of the trouble is due to lice, and not to the mange parasite.

POISONOUS PLANTS.

Although the various poisonous weeds on the range are a constant menace to the stockmen, and have cut down the profits in many cases to the point of bankruptcy, yet there seems to be no general knowledge as to the identity of these plants, or the best means of contending with them. As fast as I can get to the various sections of the State, I am locating the various toxic plants which are doing the most damage. When the map is completed I hope, with your approval, to issue a bulletin locating the sections where various poisonous plants are known to exist; cuts with full description to aid the stockmen in their identification, suitable antidote, and, what is of vastly more practical importance, the time of year when they are to be especially avoided.

Respectfully submitted,

GEORGE H. GLOVER,
Veterinarian.

REPORT OF THE IRRIGATION ENGINEER.

To the Director:

During the sixteen years that this section of the Experiment Station has been under my charge, the same general plan of investigation has been carried on, as given in one of the earliest reports. It was soon realized that the plan then given was one which would require a long time, even with abundant means, and, with lack of means, as was the case, that the whole scheme as then planned could not be taken up at once. Nevertheless, it has been the guiding plan. It has been the attempt to take up various phases of the general investigation, and these special investigations, fairly complete in themselves, nevertheless are parts of a larger and more comprehensive plan. Some of the more recent investigations have had extensive bearings, and their publication has been held for complete results. Some of these investigations have been largely depended on to protect the State, and whole irrigated West, from the attacks based largely on a lack of knowledge of conditions. They are serious, inasmuch as the proper solution of the question depends on the facts of investigation.

The investigations of the year have been largely: A continuation of the investigations to determine the amount of water actually used in irrigation, by maintaining a careful and constant record of the whole amount of water used on selected canals; an investigation of the amount of water returned from irrigation, this extending over a large part of the State; a study of the relation of the forests to the maintenance and preservation of the water supply. In addition to these there have been numerous subsidiary investigations, as well as the continuation of the regular observations in meteorology.

The relations to the office of State Engineer have put at our disposal a large amount of records, which, while not having been made for the particular purposes of our investigation, have value as rendering a means for the comparison of our results with larger field, and co-operation has been possible which has been helpful to both.

In the further measurements of seepage, these have been extended to all the tributaries of the Platte, and the basin, as a whole, has now been measured, and the records for several years available. The forecast made in Bulletin 33, based on the investigations then made, have been more than made good. The amount of such return waters has been shown to be constantly increasing, and has become of increasing importance in the public wealth of the State. More than one hundred thousand acres in the val-

ley of the Platte is thus enabled to be irrigated, and, with the development of the means of utilizing this supply, two or three times as much is possible.

For a number of years some attention has been given to the study of the relation of the forest areas on our mountain watersheds to the water supply, and, therefore, their important function in the agriculture of the State. The observations of the earlier years led to the growing belief that their importance lay in their relation to snow preservation. Some of the earlier observations were embodied in Bulletin 55, and the attempt was there made to render the condition of some of the inaccessible regions evident by the aid of photographs. Since then there has been the desire to make study of the higher elevations during other portions of the year, as during the winter. The higher elevations are then deserted by human life; they are inaccessible except to the adventurous of great physical endurance, and the visitor attempts them at the risk of his life. The question had been occassionally discussed for some years with mountaineers, and especially with Mr. Enos A. Mills, who had been an observer for the Experiment Station for a number of years. Some arrangements were discussed in detail in the fall of 1902, and arrangements made for a joint trip in midwinter. As it happened, other pressing duties took me from the State, and made it necessary for me to give up the attempt, but Mr. Mills made a series of trips to high elevations, including the top of Long's peak, and gained encouragement in the attempts. The State Engineer is required by law to make investigation of the snowfall and determine the probable flow of the streams, and, with the combination of the two purposes and the funds available from the two sources, it was possible to arrange with Mr. Mills to devote a large part of the winter of 1903-4 to study of this kind. A camera was a constant attendant, and a series of unique photographs secured of the winter conditions at high altitudes. Trips were made on snowshoes, and are often of extreme danger. It is doubtful if such an investigation will again be undertaken soon, for the combination of qualities is unusual, and the risks are so great that no pay can be compensation.

Some co-operative investigations were begun with the United States Department of Agriculture. These included the measurement of water, and the use of concrete in hydraulic structures of irrigation. Mr. S. S. L. Boothroyd was entrusted with the first, and Mr. P. J. Preston with the second. Before the first was completed, though much of the field work had been done, Mr. Boothroyd resigned, in order to accept a position as instructor at Cornell University.

Some of the important lines of investigation are completed. The selection of lines has been directed in the past by the fact that there was neither laboratory nor funds, and consequently we were forced to take up investigations in the laboratory available in

the surrounding canals. This has had both advantages and disadvantages. To obtain the best results, room for laboratory investigation is necessary, and now some of the most important part of the investigations to be made should be with laboratory assistance. In the course of the work of the series of years, a large amount of valuable records have been obtained. In case of loss these could never be replaced. The loss would not be one to the investigator, or the station, but to the State, because many of the important questions now affecting the interests of the State depend, to a large extent, on these investigations. The building provided by the last Legislature, but for which the funds were unavailable, was to have increased rooms for these investigations, and safety vaults, and both are very much needed.

Respectfully submitted,

L. G. CARPENTER.

REPORT OF THE ARKANSAS VALLEY FIELD AGENT.

To the Director:

I desire to submit the following report as a general outline of the work of the field agent for the season of 1904:

The work has largely been a continuation of the work of previous years in co-operation with farmers, and to a limited extent, experimental work that did not involve expensive labor bills, was conducted on the Experiment Station property by the field agent, or in co-operation with the tenant.

Some of the co-operative work has not been very satisfactory in securing specific results, as they are so affected by factors that are beyond control. As it is impossible to dictate if a farmer changes his plan, even if it seriously affects an experiment, although the field work has been of great value in getting general results, and keeping in touch with the work that farmers are doing in the experimental line.

A brief resume of the work might be given, as follows:

Beets. Under this topic several lines of investigation might be classed. 1. A plan to further study the development of "curly top" in beets was prevented by the fact that there was no "curly top" developed in the beet fields in this section of the State the past season; and the reason why it did not is as much a mystery as the appearance was last year.

2. Some injury to beets was caused by insects; "the garden web worm" infested several fields around Rocky Ford. We assisted in spraying several fields, and reported and sent in material of the work to the Department of Entomology of the College.

3. Notes and observations of some fertilizer on beets have been made, but as the harvest is not complete the results have not been secured. This work is being conducted by the United States Department of Agriculture, and, under the same direction, and at their expense, about one acre of land on the Experiment Station was sown to beets with the seed that was produced here in 1903. About two tons of mother beets of several types have been secured and siloed.

Resistant Beet Seed to "Curly Top." About one hundred specimens of practically normal beets were selected from the blighted fields in 1903. These were set out on the Experiment Station, and all but three died with curly top that still affected them. The three others all produced seed, and did not appear to be injured by anything. One of the three produced a pound

of good seed. It was apparently a "survival of the fittest," and if the product of this seed should prove as resistant as the mother beet, this pound of seed will be a valuable acquisition to the beet industry.

Early Cantaloupes. A study of cantaloupe fields was made to determine some of the elements that were essential to early melons, and some very interesting conclusions were reached in relation to root growth, methods of cultivation, irrigation, and fertility. Hot beds were tested to produce early cantaloupes, and field observations were made on the effects of commercial fertilizers. We desire to furnish a more extended report on this topic for publication as a bulletin.

Rust Resistant Cantaloupe. Continued field observations were made to develop a resistant cantaloupe. A comparative test of five different strains of seed was made on the Station, with the conditions uniform. The season was especially favorable for the development of rust and the fields around Rocky Ford were entirely dead and dried up three or four weeks before the first frost occurred. One strain of seed revealed marked resistant traits. The rows of this kind were green when all the other varieties in the test were dead and brown. This contrast is shown in Plate 56, that shows adjacent hills taken September 24. This same fact was noticed in several fields where this variety was planted, and in this variety some hills were much more resistant than others, and from these most favorable hills seed of different individual melons was saved to carry on this experiment, which promises great value to the melon industry.

Alfalfa Sown With Cantaloupes. The seeding of land to alfalfa is usually the loss of a season's profit on the land, as the first year's hay crop, either with or without a grain nurse crop, does not more than pay the cost of seeding on the small farms. A plan to sow alfalfa seed with cantaloupes, just before the vines begin running, was tried on eight acres of the Experiment Station. The seed was sown with a broadcast seeder, July 1, just as the vines were starting. The seed was cultivated in, and the melon rows furrowed out and irrigated. As far as the water soaked, a perfect stand of alfalfa resulted. The alfalfa did not injure the cantaloupes, as the alfalfa was too small till the vines died in the fall, when the alfalfa made a good growth. Had the melons been furrowed with two furrows and irrigated, a perfect stand of alfalfa would doubtless have resulted. With one furrow, just about one-half of the ground has a good stand. The cantaloupes yielded about at the rate of 150 crates per acre, and, from present prospects, with very little alfalfa sown in the spring, three good crops of hay can be cut in 1905 from the land that grew a good crop of cantaloupes in 1904, which plan will practically gain a year in a crop rotation of alfalfa and other crops.

Other observations and tests were made in co-operation with the Department of Entomology of the College, on thrips, on toma-

toes and alfalfa, and several tests were made on the carrying quality of cantaloupes picked at different stages. There has been a continued call by the commission men to pick melons greener. The result of our few tests was that the green melon is inferior in quality. There is need of some more work along this line to establish just to what stage of ripeness and greenness the market will stand. There is but little doubt that the past season's market disasters were due, in part, to green, unmarketable melons.

Respectfully submitted,

PHILO K. BLINN.

Rocky Ford, Colo., November 15, 1904.

THE PLAINS SUB-STATION.

To the Director:

I have the honor to submit herewith a report for the year 1904, of the Experiment Sub-Station of the Plains.

General Conditions. We had a very dry winter and spring. The first moisture to speak of was a rain on the 24th day of April, putting the ground in fair condition, and farm work was commenced at once. There were seven acres of White Australian corn planted on the 17th and 18th of May, which gave a yield of twenty-five bushels per acre.

On May the 20th there was planted one acre of corn of a large variety seed grown in Clark county, Illinois, which failed to produce ears, except on some low land, where it had the benefit of an extra amount of water during the rainy season. This made good ears, but was rather soft when frost came, on the 13th day of September. This will be planted next season, to see what the result will be by becoming acclimated. Further results from above mentioned planting was one ton of good fodder.

On the same date there was planted two acres of Kaffir corn, which was cut September 9, and yielded two tons per acre.

There was also planted, on the same date, one acre of Pencillaria, the seed being very small. I think it was covered too deep, as the ground was very mellow. Result, a very poor stand.

This plat of ground was planted to cane on July 1, which grew to the height of five feet, and formed heads; was cut September 15, making about one and one-half tons of dry feed.

On May 21 there was planted five acres of cane, of a very early variety, name unknown; yielded about one and one-half tons to the acre. This is one of the best canes that I have ever found for late planting, as it can usually be planted any time before the first day of July, and will ordinarily mature.

There was planted, on July 22, five acres of cane, seed from Barteldes, billed "Kansas Orange," a very good cane yielding two tons per acre.

On the 23d day of May there was planted five acres of cane, seed Early Orange, which yielded about the same as above, but very little of the seed matured, and only a portion of it showed heads. Result, ten tons of fodder.

All cultivated crops were put in with the lister drill, well harrowed and cultivated twice; cut between September 9 and 15.

From September 27 to 30, over four inches of water fell, accompanied by a heavy wind, thereby damaging much of the feed in the shock.

There was sown, on June 10, ten acres of millet. The ground had been previously plowed at a depth of four inches, and packed with a Campbell sub-surface packer. Seed was sown broadcast and harrowed in. This crop was cut August 27, yielding about one thousand pounds per acre.

Potatoes. There was planted, on the 1st of April, four bushels of Early Ohio potatoes, which produced tubers fit for the table June 27. From the 7th to the 17th of July there were sold eleven hundred pounds, at 3½ cents per pound.

Orchard. The orchard has done well during the last year. The trees have been well cared for, but not pruned as heavy as they should have been. The growth of wood has been very prolific.

In regard to fruit, there was about one hundred pounds of plums, three hundred pounds of cherries, and thirty bushels of apples, some very fine. The principal bearers this season were the Ben Davis, Winesap and the Jenneten.

We had a few peaches, the first ever grown in the county, which were fair size and of a very delicious flavor; variety unknown, as I have no chart of the trees.

There have been ten acres of wheat and rye sown at the Station this fall. While sown late, it looks very promising.

Respectfully submitted,

J. B. ROBERTSON,
In Charge.

Cheyenne Wells, Colo., December 16, 1904.